3248

CONVERSATIONS

ON

CHEMISTRY.

VOL. II.

Lingigie Aggiö 1820

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3248

CONVERSATIONS

ON

CHEMISTRY;

IN WHICH

THE ELEMENTS OF THAT SCIENCE

ARE

FAMILIARLY EXPLAINED

AND

ILLUSTRATED BY EXPERIMENTS.

IN TWO VOLUMES.

The Sixth Edition, revised, corrected, and enlarged.

VOL. II.

ON COMPOUND BODIES.

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CONVERSATIONS

ON

CHEMISTRY.

CONVERSATION XIII.

ON THE ATTRACTION OF COMPOSITION.

MRS. B.

Having completed our examination of the simple or elementary bodies, we are now to proceed to those of a compound nature; but before we enter on this extensive subject, it will be necessary to make you acquainted with the principal laws by which chemical combinations are governed.

You recollect, I hope, what we formerly said of the nature of the attraction of composition, or chemical attraction, or affinity, as it is also called?

EMILY.

Yes, I think, perfectly; it is the attraction that

subsists between bodies of a different nature, which occasions them to combine and form a compound, when they come in contact, and, according to Sir H. Davy's opinion, this effect is produced by the attraction of the opposite electricities, which prevail in bodies of different kinds.

MRS. B.

Very well; your definition comprehends the first law of chemical attraction, which is, that *it takes place only between bodies of a different nature*; as, for instance, between an acid and an alkali; between oxygen and a metal, &c.

CAROLINE.

That we understand of course; for the attraction between particles of a similar nature is that of aggregation, or cohesion, which is independent of any chemical power.

MRS. B.

The 2d law of chemical attraction is, that *it takes place only between the most minute particles of bodies*; therefore, the more you divide the particles of the bodies to be combined, the more readily they act upon each other.

CAROLINE.

That is again a circumstance which we might

have supposed, for the finer the particles of the two substances are, the more easily and perfectly they will come in contact with each other, which must greatly facilitate their union. It was for this purpose, you said, that you used iron filings, in preference to wires or pieces of iron, for the decomposition of water.

MRS. B.

It was once supposed that no mechanical power could divide bodies into particles sufficiently minute for them to act on each other; and that, in order to produce the extreme division requisite for a chemical action, one, if not both of the bodies, should be in a fluid state. There are, however, a few instances in which two solid bodies, very finely pulverized, exert a chemical action on one another; but such exceptions to the general rule are very rare indeed.

EMILY.

In all the combinations that we have hitherto seen, one of the constituents has, I believe, been either liquid or aëriform. In combustions, for instance, the oxygen is taken from the atmosphere, in which it existed in the state of gas; and whenever we have seen acids combine with metals or with alkalies, they were either in a liquid or an aëriform state.

MRS. B.

The 3d law of chemical attraction is, that *it can take place between two, three, four, or even a greater number of bodies.*

CAROLINE.

Oxyds and acids are bodies composed of two constituents; but I recollect no instance of the combination of a greater number of principles.

MRS. B.

The compound salts, formed by the union of the metals with acids, are composed of three principles. And there are salts formed by the combination of the alkalies with the earths which are of a similar description.

CAROLINE.

Are they of the same kind as the metallic salts?

MRS. B.

Yes; they are very analogous in their nature, although different in many of their properties.

A methodical nomenclature, similar to that of the acids, has been adopted for the compound salts. Each individual salt derives its name from its constituent parts, so that every name implies a knowledge of the composition of the salt.

The three alkalies, the alkaline earths, and the

metals, are called *salifiable bases* or *radicals*; and the acids, *salifying principles*. The name of each salt is composed both of that of the acid and the salifiable base; and it terminates in *at* or *it*, according to the degree of the oxygenation of the acid. Thus, for instance, all those salts which are formed by the combination of the sulphuric acid with any of the salifiable bases are called *sulphats*, and the name of the radical is added for the specific distinction of the salt; if it be potash, it will compose a *sulphat of potash*; if ammonia, *sulphat of ammonia*, &c.

EMILY.

The crystals which we obtained from the combination of iron and sulphuric acid were therefore *sulphat of iron*?

MRS. B.

Precisely; and those which we prepared by dissolving copper in nitric acid, *nitrat of copper*, and so on. — But this is not all; if the salt be formed by that class of acids which ends in *ous*, (which you know indicates a less degree of oxygenation,) the termination of the name of the salt will be in *it*, as *sulphit of potash*, *sulphit of ammonia*, &c.

EMILY.

There must be an immense number of compound

salts, since there is so great a variety of salifiable radicals, as well as of salifying principles.

MRS. B.

Their real number cannot be ascertained, since it increases every day. But we must not proceed further in the investigation of the compound salts, until we have completed the examination of the nature of the ingredients of which they are composed.

The 4th law of chemical attraction is, that *a change of temperature always takes place at the moment of combination.* This arises from the extrication of the two electricities in the form of caloric, which always occurs when bodies unite; and also sometimes in part from a change of capacity of the bodies for heat, which always takes place when the combination is attended with an increase of density, but more especially when the compound passes from the liquid to the solid form. I shall now show you a striking instance of a change of temperature from chemical union, merely by pouring some nitrous acid on this small quantity of oil of turpentine — the oil will instantly combine with the oxygen of the acid, and produce a considerable change of temperature.

CAROLINE.

What a blaze! The temperature of the oil and

the acid must be greatly raised, indeed, to produce such a violent combustion.

MRS. B.

There is, however, a peculiarity in this combustion, which is, that the oxygen, instead of being derived from the atmosphere alone, is principally supplied by the acid itself.

EMILY.

And are not all combustions instances of the change of temperature produced by the chemical combination of two bodies?

MRS. B.

Undoubtedly; when oxygen loses its gaseous form, in order to combine with a solid body, it becomes condensed, and the caloric evolved produces the elevation of temperature. The specific gravity of bodies is at the same time altered by chemical combination; for in consequence of a change of capacity for heat, a change of density must be produced.

CAROLINE.

That was the case with the sulphuric acid and water, which, by being mixed together, gave out a great deal of heat, and increased in density.

MRS. B.

The 5th law of chemical attraction is, that *the properties which characterise bodies, when separate, are altered or destroyed by their combination.*

CAROLINE.

Certainly; what, for instance, can be so different from water as the hydrogen and oxygen gases?

EMILY.

Or what more unlike sulphat of iron than iron or sulphuric acid?

MRS. B.

Every chemical combination is an illustration of this rule. But let us proceed—

The 6th law is, that *the force of chemical affinity between the constituents of a body is estimated by that which is required for their separation.* This force is not always proportional to the facility with which bodies unite; for manganese, for instance, which, you know, is so much disposed to unite with oxygen that it is never found in a metallic state, yields it more easily than any other metal.

EMILY.

But, Mrs. B., you speak of estimating the force of attraction between bodies, by the force required

to separate them; how can you measure these forces?

MRS. B.

They cannot be precisely *measured*, but they are comparatively ascertained by experiment, and can be represented by numbers which express the relative degrees of attraction.

The 7th law is, that *bodies have amongst themselves different degrees of attraction.* Upon this law, (which you may have discovered yourselves long since,) the whole science of chemistry depends; for it is by means of the various degrees of affinity which bodies have for each other, that all the chemical compositions and decompositions are effected. Every chemical fact or experiment is an instance of the same kind; and whenever the decomposition of a body is performed by the addition of any single new substance, it is said to be effected by *simple elective attractions.* But it often happens that no simple substance will decompose a body, and that, in order to effect this, you must offer to the compound a body which is itself composed of two, or sometimes three principles, which would not, each separately, perform the decomposition. In this case there are two new compounds formed in consequence of a reciprocal decomposition and recomposition. All instances of this kind are called *double elective attractions.*

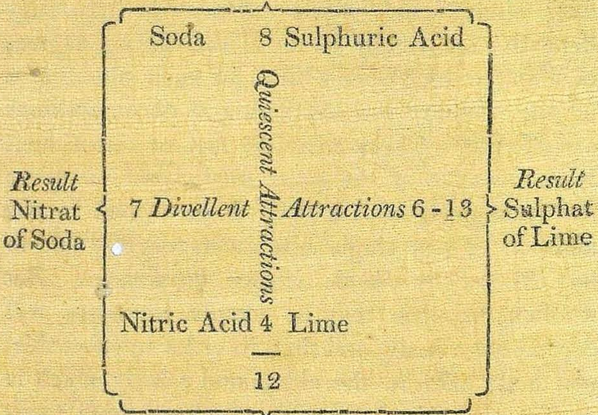
CAROLINE.

I confess I do not understand this clearly.

MRS. B.

You will easily comprehend it by the assistance of this diagram, in which the reciprocal forces of attraction are represented by numbers:

Original Compound
Sulphat of Soda.



Original Compound
Nitrat of Lime.

We here suppose that we are to decompose sulphat of soda; that is, to separate the acid from

the alkali; if, for this purpose we add some lime, in order to make it combine with the acid, we shall fail in our attempt, because the soda and the sulphuric acid attract each other by a force which is superior, and (by way of supposition) is represented by the number 8; while the lime tends to unite with this acid by an affinity equal only to the number 6. It is plain, therefore, that the sulphat of soda will not be decomposed, since a force equal to 8 cannot be overcome by a force equal only to 6.

CAROLINE.

So far, this appears very clear.

MRS. B.

If, on the other hand, we endeavour to decompose this salt by nitric acid, which tends to combine with soda, we shall be equally unsuccessful, as nitric acid tends to unite with the alkali by a force equal only to 7.

In neither of these cases of simple elective attraction, therefore, can we accomplish our purpose. But let us previously combine together the lime and nitric acid, so as to form a nitrat of lime, a compound salt, the constituents of which are united by a power equal to 4. If then we present this compound to the sulphat of soda, a decomposition will ensue, because the sum of the forces

which tend to preserve the two salts in their actual state is not equal to that of the forces which tend to decompose them, and to form new combinations. The nitric acid, therefore, will combine with the soda, and the sulphuric acid with the lime.

CAROLINE.

I understand you now very well. This double effect takes place because the numbers 8 and 4, which represent the degrees of attraction of the constituents of the two original salts, make a sum less than the numbers 7 and 6, which represent the degrees of attraction of the two new compounds that will in consequence be formed.

MRS. B.

Precisely so.

CAROLINE.

But what is the meaning of *quiescent* and *divellent* forces, which are written in the diagram?

MRS. B.

Quiescent forces are those which tend to preserve compounds in a state of rest, or such as they actually are: divellent forces, those which tend to destroy that state of combination, and to form new compounds.

These are the principal circumstances relative to the doctrine of chemical attractions, which

have been laid down as rules by modern chemists; a few others might be mentioned respecting the same theory, but of less importance, and such as would take us too far from our plan. I should, however, not omit to mention that Mr. Berthollet, a celebrated French chemist, has questioned the uniform operation of elective attraction, and has advanced the opinion, that, in chemical combinations, the changes which take place depend not only upon the affinities, but also, in some degree, on the respective quantities of the substances concerned, on the heat applied during the process, and some other circumstances.

CAROLINE.

In that case, I suppose, there would hardly be two compounds exactly similar, though composed of the same materials?

MRS. B.

On the contrary, it is found that a remarkable uniformity prevails, as to proportions, between the ingredients of bodies of similar composition. Thus water, as you may recollect to have seen in a former conversation, is composed of two volumes of hydrogen gas to one of oxygen, and this is always found to be precisely the proportion of its constituents, from whatever source the water be derived. The same uniformity prevails with regard to the various salts; the acid and alkali, in

each kind of salt, being always found to combine in the same proportions. Sometimes, it is true, the same acid, and the same alkali are capable of making two distinct kinds of salts; but in all these cases it is found that one of the salts contains just twice, or in some instances, thrice as much acid, or alkali, as the other.

EMILY.

If the proportions in which bodies combine are so constant and so well defined, how can Mr. Berthollet's remark be reconciled with this uniform system of combination?

MRS. B.

Great as that philosopher's authority is in chemistry, it is now generally supposed that his doubts on this subject were in a great degree groundless, and that the exceptions he has observed in the laws of definite proportions, have been only apparent, and may be accounted for consistently with those laws.

CAROLINE.

Pray, Mrs. B., can you decompose a salt by means of electricity, in the same way as we decompose water?

MRS. B.

Undoubtedly; and I am glad this question occurred to you, because it gives me an opportunity

of showing you some very interesting experiments on the subject.

If we dissolve a quantity, however small, of any salt in a glass of water, and if we plunge into it the extremities of the wires which proceed from the two ends of the Voltaic battery, the salt will be gradually decomposed, the acid being attracted by the positive, and the alkali by the negative wire.

EMILY.

But how can you render that decomposition perceptible?

MRS. B.

By placing in contact with the extremities of each wire, in the solution, pieces of paper stained with certain vegetable colours, which are altered by the contact of an acid or an alkali. Thus this blue vegetable preparation called litmus, becomes red when touched by an acid; and the juice of violets becomes green by the contact of an alkali.

But the experiment can be made in a much more distinct manner, by receiving the extremities of the wires into two different vessels, so that the alkali shall appear in one vessel and the acid in the other.

CAROLINE.

But then the Voltaic circle will not be completed; how can any effect be produced?

MRS. B.

You are right; I ought to have added that the two vessels must be connected together by some interposed substance capable of conducting electricity. A piece of moistened cotton-wick answers this purpose very well. You see that the cotton (PLATE XIII. fig. 2. c.) has one end immersed in one glass and the other end in the other, so as to establish a communication between any fluids contained in them. We shall now put into each of the glasses a little glauber salt, or sulphat of soda, (which consists of an acid and an alkali,) and then we shall fill the glasses with water, which will dissolve the salt. Let us now connect the glasses by means of the wires (e, d,) with the two ends of the battery, thus . . . .

CAROLINE.

The wires are already giving out small bubbles; is this owing to the decomposition of the salt?

MRS. B.

No; these are bubbles produced by the decomposition of the water, as you saw in a former experiment. In order to render the separation of the acid from the alkali visible, I pour into the glass (a), which is connected with the positive wire, a few drops of a solution of litmus,

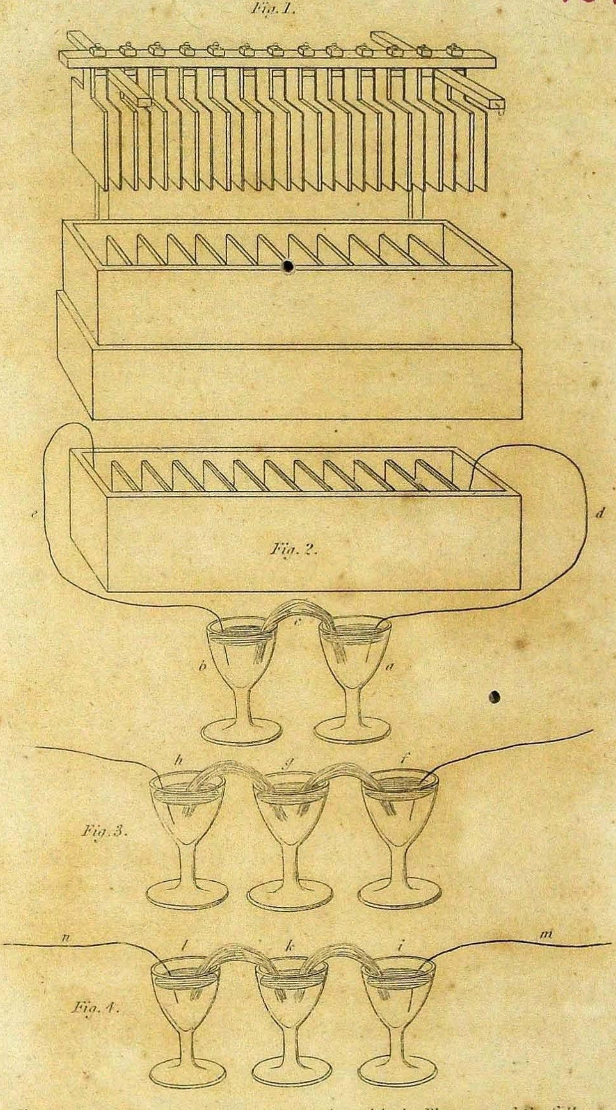


Fig. 1. Voltaic Battery of improved construction with the Plates out of the Cells.
Fig. 2. 3 & 4. Instances of Chemical decomposition by the Voltaic Battery.

which the least quantity of acid turns red; and into the other glass (b), which is connected with the negative wire, I pour a few drops of the juice of violets . . . .

EMILY.

The blue solution is already turning red all round the wire.

CAROLINE.

And the violet solution is beginning to turn green. This is indeed very singular!

MRS. B.

You will be still more astonished when we vary the experiment in this manner:—These three glasses (fig. 3. f, g, h,) are, as in the former instance, connected together by wetted cotton, but the middle one alone contains a saline solution, the two others containing only distilled water, coloured as before by vegetable infusions. Yet, on making the connection with the battery, the alkali will appear in the negative glass (h), and the acid in the positive glass (f), though neither of them contained any saline matter.

EMILY.

So that the acid and alkali must be conveyed right and left from the central glass, into the

other glasses, by means of the connecting moistened cotton?

MRS. B.

Exactly so; and you may render the experiment still more striking, by putting into the central glass (k, fig. 4.) an alkaline solution, the glauber salt being placed into the negative glass (l), and the positive glass (i) containing only water. The acid will be attracted by the positive wire (m), and will actually appear in the vessel (i), after passing through the alkaline solution (k), without combining with it, although, you know, acids and alkalies are so much disposed to combine. — But this conversation has already much exceeded our usual limits, and we cannot enlarge more upon this interesting subject at present.

CONVERSATION XIV.

ON ALKALIES.

MRS. B.

HAVING now given you some idea of the laws by which chemical attractions are governed, we may proceed to the examination of bodies which are formed in consequence of these attractions.

The first class of compounds that present themselves to our notice, in our gradual ascent to the most complicated combinations, are bodies composed of only two principles. The sulphurets, phosphurets, carburets, &c. are of this description; but the most numerous and important of these compounds are the combinations of oxygen with the various simple substances with which it has a tendency to unite. Of these you have already acquired some knowledge, but it will be necessary to enter into further particulars respecting the nature and properties of those most deserving our notice. Of this class are the ALKALIES and the EARTHS, which we shall successively examine.

We shall first take a view of the alkalies, of which

there are three, viz. POTASH, SODA, and AMMONIA. The two first are called *fixed alkalies*,* because they exist in a solid form at the temperature of the atmosphere, and require a great heat to be volatilised. They consist, as you already know, of metallic bases combined with oxygen. In potash, the proportions are about eighty-six parts of potassium to fourteen of oxygen; and in soda, seventy-seven parts of sodium to twenty-three of oxygen. The third alkali, ammonia, has been distinguished by the name of *volatile alkali*, because its natural form is that of gas. Its composition is of a more complicated nature, of which we shall speak hereafter.

Some of the earths bear so strong a resemblance in their properties to the alkalies, that it is difficult to know under which head to place them. The celebrated French chemist, Fourcroy, has classed two of them (barytes and strontites) with the alkalies; but as lime and magnesia have almost an equal title to that rank, I think it better not to se-

* It has already been stated that a third fixed alkali has lately been discovered by Mr. Arforedson, which has been called *lithion*. It was first found in a Swedish mineral called *petalite*; but has since been detected in some other minerals. Though this alkali resembles potash and soda in its general properties, yet it is decidedly an alkaline substance of its own, capable of forming different salts with the acids, and having in particular the property of combining with much greater proportions of acid than the other alkalies.

parate them, and therefore have adopted the common method of classing them with the earths, and of distinguishing them by the name of *alkaline earths.*

The general properties of alkalies are, an acrid burning taste, a pungent smell, and a caustic action on the skin and flesh.

CAROLINE.

I wonder they should be caustic, Mrs. B., since they contain so little oxygen.

MRS. B.

Whatever substance has an affinity for any one of the constituents of animal matter, sufficiently powerful to decompose it, is entitled to the appellation of caustic. The alkalies, in their pure state, have a very strong attraction for water, for hydrogen, and for carbon, which, you know, are the constituent principles of oil, and it is chiefly by absorbing these substances from animal matter that they effect its decomposition; for, when diluted with a sufficient quantity of water, or combined with any oily substance, they lose their causticity.

But, to return to the general properties of alkalies — they change, as we have already seen, the colour of syrup of violets, and other blue vegetable infusions, to green; and have, in general, a very great tendency to unite with acids, although the respective qualities of these two classes of bodies form a remarkable contrast.

We shall examine the result of the combination of acids and alkalies more particularly hereafter. It will be sufficient at present to inform you, that whenever acids are brought in contact with alkalies, or alkaline earths, they unite with a remarkable eagerness, and form compounds perfectly different from either of their constituents; these bodies are called *neutral or compound salts.*

The dry white powder which you see in this phial is pure caustic POTASH; it is very difficult to preserve it in this state, as it attracts, with extreme avidity, the moisture from the atmosphere, and if the air were not perfectly excluded, it would, in a very short time, be actually melted.

EMILY.

It is then, I suppose, always found in a liquid state?

MRS. B.

No; it exists in nature in a great variety of forms and combinations, but is never found in its pure separate state; it is combined with carbonic acid, with which it exists in every part of the vegetable kingdom, and is most commonly obtained from the ashes of vegetables, which are the residue that remains after all the other parts have been volatilised by combustion.

CAROLINE.

But you once said, that after all the volatile parts of a vegetable were evaporated, the substance that remained was charcoal?

MRS. B.

I am surprised that you should still confound the processes of volatilisation and combustion. In order to procure charcoal, we evaporate such parts as can be reduced to vapour by the operation of heat alone; but when we *burn* the vegetable, we burn the carbon also, and convert it into carbonic acid gas.

CAROLINE.

That is true; I hope I shall make no more mistakes in my favourite theory of combustion.

MRS. B.

Potash derives its name from the *pots* in which the vegetables, from which it was obtained, used formerly to be burnt; the alkali remained mixed with the ashes at the bottom, and was thence called potash.

EMILY.

The ashes of a wood-fire, then, are potash, since they are vegetable ashes?

MRS. B.

They always contain more or less potash, but

are very far from consisting of that substance alone, as they are a mixture of various earths and salts which remain after the combustion of vegetables, and from which it is not easy to separate the alkali in its pure form. The process by which potash is obtained, even in the imperfect state in which it is used in the arts, is much more complicated than simple combustion. It was once deemed impossible to separate it entirely from all foreign substances, and it is only in chemical laboratories that it is to be met with in the state of purity in which you find it in this phial. Wood-ashes are, however, valuable for the alkali which they contain, and are used for some purposes without any further preparation. Purified in a certain degree, they make what is commonly called *pearl-ash*, which is of great efficacy in taking out grease, in washing linen, &c.; for potash combines readily with oil or fat, with which it forms a compound well known to you under the name of *soap*.

CAROLINE.

Really! Then I should think it would be better to wash all linen with pearl-ash than with soap, as, in the latter case, the alkali being already combined with oil, must be less efficacious in extracting grease.

MRS. B.

Its effect would be too powerful on fine linen,

and would injure its texture; pearl-ash is therefore only used for that which is of a strong coarse kind. For the same reason you cannot wash your hands with plain potash; but, when mixed with oil in the form of soap, it is soft as well as cleansing, and is therefore much better adapted to the purpose.

Caustic potash, as we already observed, acts on the skin, and animal fibre, in virtue of its attraction for water and oil, and converts all animal matter into a kind of saponaceous jelly.

EMILY.

Are vegetables the only source from which potash can be derived?

MRS. B.

No: for though far most abundant in vegetables, it is by no means confined to that class of bodies, being found also on the surface of the earth, mixed with various minerals, especially with earths and stones, whence it is supposed to be conveyed into vegetables by the roots of the plant. It is also met with, though in very small quantities, in some animal substances. The most common state of potash is that of *carbonat;* I suppose you understand what that is?

EMILY.

I believe so; though I do not recollect that you ever mentioned the word before. If I am not mis-

taken, it must be a compound salt, formed by the union of carbonic acid with potash.

MRS. B.

Very true; you see how admirably the nomenclature of modern chemistry is adapted to assist the memory; when you hear the name of a compound, you necessarily learn what are its constituent parts; and when you are acquainted with these constituents, you can immediately name the compound which they form.

CAROLINE.

Pray, how were bodies arranged and distinguished before this nomenclature was introduced?

MRS. B.

Chemistry was then a much more difficulty study; for every substance had an arbitrary name, which it derived either from the person who discovered it, as *Glauber's salts* for instance; or from some other circumstance relative to it, though quite unconnected with its real nature, as *potash*.

These names have been retained for some of the simple bodies; for as this class is not numerous, and therefore can easily be remembered, it has not been thought necessary to change them.

EMILY.

Yet I think it would have rendered the new nomenclature more complete to have methodised

the names of the elementary, as well as of the compound bodies, though it could not have been done in the same manner. But the names of the simple substances might have indicated their nature, or, at least, some of their principal properties; and if, like the acids and compound salts, all the simple bodies had a similar termination, they would have been immediately known as such. So complete and regular a nomenclature would, I think, have given a clearer and more comprehensive view of chemistry than the present, which is a medley of the old and new terms.

MRS. B.

But you are not aware of the difficulty of introducing into science an entire set of new terms; it obliges all the teachers and professors to go to school again, and if some of the old names, that are least exceptionable, were not left as an introduction to the new ones, few people would have had industry and perseverance enough to submit to the study of a completely new language; and the inferior classes of artists, who can only act from habit and routine, would, at least for a time, have felt material inconvenience from a total change of their habitual terms. From these considerations, Lavoisier and his colleagues, who invented the new nomenclature, thought it most prudent to leave a few links of the old chain, in

order to connect it with the new one. Besides, you may easily conceive the inconvenience which might arise from giving a regular nomenclature to substances, the simple nature of which is always uncertain; for the new names might, perhaps, have proved to have been founded in error. And, indeed, cautious as the inventors of the modern chemical language have been, it has already been found necessary to modify it in many respects. In those few cases, however, in which new terms have been adopted to designate simple bodies, these names have been so contrived as to indicate one of the chief properties of the body in question; this is the case with oxygen, which, as I explained to you, signifies generator of acids; and hydrogen generator of water. If all the elementary bodies had a similar termination, as you propose, it would be necessary to change the name of any that might hereafter be found of a compound nature, which would be very inconvenient in this age of discovery.

But to return to the alkalies. — We shall now try to melt some of this caustic potash in a little water, as a circumstance occurs during its solution very worthy of observation. — Do you feel the heat that is produced?

CAROLINE.

Yes, I do; but is not this directly contrary to

our theory of latent heat, according to which heat is disengaged when fluids become solid, and cold produced when solids are melted?

MRS. B.

The latter is really the case in all solutions; and if the solution of caustic alkalies seems to make an exception to the rule, it does not, I believe, form any solid objection to the theory. The matter may be explained thus: When water first comes in contact with the potash, it produces an effect similar to the slaking of lime, that is, the water is solidified in combining with the potash, and thus loses its latent heat; this is the heat that you now feel, and which is, therefore, produced not by the melting of the solid, but by the solidification of the fluid. But when there is more water than the potash can absorb and solidify, the latter then yields to the solvent power of the water; and if we do not perceive the cold produced by its melting, it is because it is counterbalanced by the heat previously disengaged. *

A very remarkable property of potash is the

* This defence of the general theory, however plausible, is liable to some obvious objections. The phenomenon might perhaps be better accounted for by supposing that a solution of alkali in water has less capacity for heat than either water or alkali in their separate state.

formation of glass by its fusion with siliceous earth. You are not yet acquainted with this last substance, further than its being in the list of simple bodies. It is sufficient, for the present, that you should know that sand and flint are chiefly composed of it; alone, it is infusible, but mixed with potash, it melts when exposed to the heat of a furnace, combines with the alkali, and runs into glass.

CAROLINE.

Who would ever have supposed that the same substance which converts transparent oil into such an opaque body as soap, should transform that opaque substance, sand, into transparent glass!

MRS. B.

The transparency, or opacity of bodies, does not, I conceive, depend so much upon their intimate nature, as upon the arrangement of their particles: we cannot have a more striking instance of this, than is afforded by the different states of carbon, which, though it commonly appears in the form of a black opaque body, sometimes assumes the most dazzling transparent form in nature, that of diamond, which, you recollect, is carbon, and which, in all probability, derives its beautiful transparency from the peculiar arrangement of its particles during their crystallisation.

EMILY.

I never should have supposed that the formation of glass was so simple a process as you describe it.

MRS. B.

It is by no means an easy operation to make perfect glass; for if the sand or flint, from which the siliceous earth is obtained, be mixed with any metallic particles, or other substance, which cannot be vitrified, the glass will be discoloured, or defaced, by opaque specks.

CAROLINE.

That, I suppose, is the reason why objects so often appear irregular and distorted through a common glass-window.

MRS. B.

This species of imperfection proceeds, I believe, from another cause. It is extremely difficult to prevent the lower part of the vessels, in which the materials of glass are fused, from containing a more dense vitreous matter than the upper, on account of the heavier ingredients falling to the bottom. When this happens, it occasions the appearance of veins or waves in the glass, from the difference of density in its several parts, which produces an irregular refraction of the rays of light which pass through it.

Another species of imperfection sometimes arises from the fusion not being continued for a length of time sufficient to combine the two ingredients completely, or from the due proportion of potash and silex (which are as two to one) not being carefully observed; the glass, in those cases, will be liable to alteration from the action of the air, of salts, and especially of acids, which will effect its decomposition by combining with the potash, and forming compound salts.

EMILY.

What an extremely useful substance potash is!

MRS. B.

Besides the great importance of potash in the manufactures of glass and soap, it is of very considerable utility in many of the other arts, and in its combinations with several acids, particularly the nitric, with which it forms saltpetre.

CAROLINE.

Then saltpetre must be a *nitrat of potash?* But we are not yet acquainted with the nitric acid?

MRS. B.

We shall therefore defer entering into the particulars of these combinations till we come to a general review of the compound salts. In order

to avoid confusion, it will be better at present to confine ourselves to the alkalies.

EMILY.

Cannot you show us the change of colour which you said the alkalies produced on blue vegetable infusions?

MRS. B.

Yes; very easily. I shall dip a piece of white paper into this syrup of violets, which, you see, is of a deep blue, and dyes the paper of the same colour.—As soon as it is dry, we shall dip it into a solution of potash, which, though itself colourless, will turn the paper green—

CAROLINE.

So it has, indeed! And do the other alkalies produce a similar effect?

MRS. B.

Exactly the same.—We may now proceed to SODA, which, however important, will detain us but a very short time; as in all its general properties it very strongly resembles potash; indeed, so great is their similitude, that they have been long confounded, and they can now scarcely be distinguished, except by the difference of the salts which they form with acids.

The great source of this alkali is the sea, where,

combined with a peculiar acid, it forms the salt with which the waters of the ocean are so strongly impregnated.

EMILY.

Is not that the common table salt?

MRS. B.

The very same; but again we must postpone entering into the particulars of this interesting combination, till we treat of the neutral salts. Soda may be obtained from common salt; but the easiest and most usual method of procuring it is by the combustion of marine plants, an operation perfectly analogous to that by which potash is obtained from vegetables.

EMILY.

From what does soda derive its name?

MRS. B.

From a plant called by us *soda*, and by the Arabs *kali*, which affords it in great abundance. Kali has, indeed, given its name to the alkalies in general.

CAROLINE.

Does soda form glass and soap in the same manner as potash?

MRS. B.

Yes, it does; it is of equal importance in the

arts, and is even preferred to potash for some purposes; but you will not be able to distinguish their properties till we examine the compound salts which they form with acids; we must therefore leave soda for the present, and proceed to AMMONIA, or the VO[illegible]LE ALKALI.

EMILY.

I long to hear something of this alkali; is it not of the same nature as hartshorn?

MRS. B.

Yes, it is, as you will see by-and-bye. This alkali is seldom found in nature in its pure state; it is most commonly extracted from a compound salt, called *sal ammoniac*, which was formerly imported from *Ammonia*, a region of Libya, from which both these salts and the alkali derive their names. The crystals contained in this bottle are specimens of this salt, which consists of a combination of ammonia and muriatic acid.

CAROLINE.

Then it should be called *muriat of ammonia*; for though I am ignorant what muriatic acid is, yet I know that its combination with ammonia cannot but be so called; and I am surprised to see sal ammoniac inscribed on the label.

MRS. B.

That is the name by which it has been so long known, that the modern chemists have not yet succeeded in banishing it altogether; and it is still sold under that name by druggists, though by scientific chemists it is more properly called muriat of ammonia.

CAROLINE.

Both the popular and the common name should be inscribed on labels — this would soon introduce the new nomenclature.

EMILY.

By what means can the ammonia be separated from the muriatic acid?

MRS. B.

By chemical attractions; but this operation is too complicated for you to understand, till you are better acquainted with the agency of affinities.

EMILY.

And when extracted from the salt, what kind of substance is ammonia?

MRS. B.

Its natural form, at the temperature of the atmosphere, when free from combination, is that of gas; and in this state it is called *ammoniacal gas.*

But it mixes very readily with water, and can be thus obtained in a liquid form.

CAROLINE.

You said that ammonia was more complicated in its composition than the other alkalies; pray of what principles does it consist?

MRS. B.

It was discovered a few years since, by Berthollet, a celebrated French chemist, that it consisted of about one part of hydrogen to four parts of nitrogen. Having heated ammoniaçal gas under a receiver, by causing the electrical spark to pass repeatedly through it, he found that it increased considerably in bulk, lost all its alkaline properties, and was actually converted into hydrogen and nitrogen gases; and from the latest and most accurate experiments, the proportions appear to be, one volume of nitrogen gas to three of oxygen gas.

CAROLINE.

Ammonia, therefore, has not, like the two other alkalies, a metallic basis?

MRS. B.

It is believed that it has, though it is extremely difficult to reconcile that idea with what I have just stated of its chemical nature. But the fact is, that

although this supposed metallic basis of ammonia has never been obtained distinct and separate, yet both Professor Berzelius, of Stockholm, and Sir H. Davy, have succeeded in forming a combination of mercury with the basis of ammonia, which has so much the appearanc[illegible] an amalgam, that it strongly corroborates the idea of ammonia having a metallic basis.* But these theoretical points are full of difficulties and doubts, and it would be useless to dwell any longer upon them.

Let us therefore return to the properties of volatile alkali. Ammoniacal gas is considerably lighter than oxygen gas, and only about half the weight of atmospherical air. It possesses most of the properties of the fixed alkalies; but cannot be of so much use in the arts on account of its volatile nature. It is, therefore, never employed in the manufacture of glass, but it forms soap with oils equally as well as potash and soda; it resembles them likewise in its strong attraction for water; for which reason it can be collected in a receiver over mercury only.

* This amalgam is easily obtained, by placing a globule of mercury upon a piece of muriat, or carbonat of ammonia, and electrifying this globule by the Voltaic battery. The globule instantly begins to expand to three or four times its former size, and becomes much less fluid, though without losing its metallic lustre, a change which is ascribed to the metallic basis of ammonia uniting with the mercury. This is an extremely curious experiment.

CAROLINE.

I do not understand this?

MRS. B.

Do you recollect the method which we used to collect gases in a glass receiver over water?

CAROLINE.

Perfectly.

MRS. B.

Ammoniacal gas has so strong a tendency to unite with water, that, instead of passing through that fluid, it would be instantaneously absorbed by it. We can therefore neither use water for that purpose, nor any other liquid of which water is a component part; so that, in order to collect this gas, we are obliged to have recourse to mercury, (a liquid which has no action upon it,) and a mercurial bath is used instead of a water bath, such as we employed on former occasions. Water impregnated with this gas is nothing more than the fluid which you mentioned at the beginning of the conversation — hartshorn; it is the ammoniacal gas escaping from the water which gives it so powerful a smell.

EMILY.

But there is no appearance of effervescence in hartshorn.

MRS. B.

Because the particles of gas that rise from the water are too subtle and minute for their effect to be visible.

Water diminishes in density, by being impregnated with ammoniacal gas; and this augmentation of bulk increases its capacity for caloric.

EMILY.

In making hartshorn, then, or impregnating water with ammonia, heat must be absorbed, and cold produced?

MRS. B.

That effect would take place if it was not counteracted by another circumstance; the gas is liquefied by incorporating with the water, and gives out its latent heat. The condensation of the gas more than counterbalances the expansion of the water; therefore, upon the whole, heat is produced. — But if you dissolve ammoniacal gas with ice or snow, cold is produced. — Can you account for that?

EMILY.

The gas, in being condensed into a liquid, must give out heat; and, on the other hand, the snow or ice, in being rarefied into a liquid, must absorb heat; so that, between the opposite effects, I should have supposed the original temperature would have been preserved.

MRS. B.

But you have forgotten to take into the account the rarefaction of the water (or melted ice) by the impregnation of the gas; and this is the cause of the cold which is ultimately produced.

CAROLINE.

Is the *sal volatile* (the smell of which so strongly resembles hartshorn) likewise a preparation of ammonia?

MRS. B.

It is carbonat of ammonia dissolved in water; and which, in its concrete state, is commonly called salts of hartshorn. Ammonia is caustic, like the fixed alkalies, as you may judge by the pungent effects of hartshorn, which cannot be taken internally, nor applied to delicate external parts, without being plentifully diluted with water. — Oil and acids are very excellent antidotes for alkaline poisons; can you guess why?

CAROLINE.

Perhaps, because the oil combines with the alkali, and forms soap, and thus destroys its caustic properties; and the acid converts it into a compound salt, which, I suppose, is not so pernicious as caustic alkali.

MRS. B.

Precisely so.

Ammoniacal gas, if it be mixed with atmospherical air, and a burning taper repeatedly plunged into it, will burn with a large flame of a peculiar yellow colour.

EMILY.

But pray tell me, can ammonia be procured from this Lybian salt only?

MRS. B.

So far from it, that it is contained in, and may be extracted from, all animal substances whatever. Hydrogen and nitrogen are two of the chief constituents of animal matter; it is therefore not surprising that they should occasionally meet and combine in those proportions that compose ammonia. But this alkali is more frequently generated by the spontaneous decomposition of animal substances; the hydrogen and nitrogen gases that arise from putrified bodies combine, and form the volatile alkali.

Muriat of ammonia, instead of being exclusively brought from Lybia, as it originally was, is now chiefly prepared in Europe, by chemical processes. Ammonia, although principally extracted from this salt, can also be produced by a great variety of other substances. The horns of cattle, especially those of deer, yield it in abundance, and it is from this circumstance that a solution of ammonia in water has been called hartshorn. It may likewise

be procured from wool, flesh, and bones; in a word, any animal substance whatever yields it by decomposition.

We shall now lay aside the alkalies, however important the subject may be, till we treat of their combination with acids. The next time we meet we shall examine the earths.

CONVERSATION XV.

ON EARTHS.

MRS. B.

THE EARTHS, which we are to-day to examine, are nine in number:

SILEX,	STRONTITES,
ALUMINE,	YTTRIA,
BARYTES,	GLUCINA,
LIME,	ZIRCONIA.
MAGNESIA,	

The last three are of late discovery; their properties are but imperfectly known; and, as they have not yet been applied to use, it will be unnecessary to enter into any particulars respecting them; we shall confine our remarks, therefore, to the first five. They are composed, as you have already learnt, of a metallic basis combined with oxygen; and, from this circumstance, are incombustible.

CAROLINE.

Yet I have seen turf burnt in the country, and it makes an excellent fire; the earth becomes red hot, and produces a very great quantity of heat.

MRS. B.

It is not the earth that burns, my dear, but the roots, grass, and other remnants of vegetables that are intermixed with it. The caloric, which is produced by the combustion of these substances, makes the earth red hot, and this being a bad conductor of heat, retains its caloric a long time; but were you to examine it when cooled, you would find that it had not absorbed one particle of oxygen, nor suffered any alteration from the fire. Earth is, however, from the circumstance just mentioned, an excellent radiator of heat, and owes its utility, when mixed with fuel, solely to that property. It is in this point of view that Count Rumford has recommended balls of incombustible substances to be arranged in fire-places, and mixed with the coals, by which means the caloric disengaged by the combustion of the latter is more perfectly reflected into the room, and an expense of fuel is saved.

EMILY.

I expected that the list of earths would be much more considerable. When I think of the great

variety of soils, I am astonished that there is not a greater number of earths to form them.

MRS. B.

You might, indeed, almost confine that number to four; for barytes, strontites, and the others of late discovery, act but so small a part in this great theatre, that they cannot be reckoned as essential to the general formation of the globe. And you must not confine your idea of earths to the formation of soil; for rock, marble, chalk, slate, sand, flint, and all kinds of stones, from the precious jewels to the commonest pebbles; in a word, all the immense variety of mineral products, may be referred to some of these earths, either in a simple state, or combined the one with the other, or blended with other ingredients.

CAROLINE.

Precious stones composed of earth! That seems very difficult to conceive.

EMILY.

Is it more extraordinary than that the most precious of all jewels, diamond, should be composed of carbon? But diamond forms an exception, Mrs. B.; for, though a stone, it is not composed of earth.

MRS. B.

I did not specify the exception, as I knew you were so well acquainted with it. Besides, I would call a diamond a mineral rather than a stone, as the latter term always implies the presence of some earth.

CAROLINE.

I cannot conceive how such coarse materials can be converted into such beautiful productions.

MRS. B.

We are very far from understanding all the secret resources of nature; but I do not think the spontaneous formation of the crystals, which we call precious stones, one of the most difficult phenomena to comprehend.

By the slow and regular work of ages, perhaps of hundreds of ages, these earths may be gradually dissolved by water, and as gradually deposited by their solvent in the undisturbed process of crystallisation. The regular arrangement of their particles, during their re-union in a solid mass, gives them that brilliancy, transparency, and beauty, for which they are so much admired; and renders them in appearance so totally different from their rude and primitive ingredients.

CAROLINE.

But how does it happen that they are spontaneously dissolved, and afterwards crystallised?

MRS. B.

The scarcity of many kinds of crystals, as rubies, emeralds, topazes, &c. shows that their formation is not an operation very easily carried on in nature. But cannot you imagine that when water, holding in solution some particles of earth, filters through the crevices of hills or mountains, and at length dribbles into some cavern, each successive drop may be slowly evaporated, leaving behind it the particle of earth which it held in solution? You know that crystallisation is more regular and perfect, in proportion as the evaporation of the solvent is slow and uniform; nature, therefore, who knows no limit of time, has, in all works of this kind, an infinite advantage over any artist who attempts to imitate such productions.

EMILY.

I can now conceive that the arrangement of the particles of earth, during crystallisation, may be such as to occasion transparency, by admitting a free passage to the rays of light; but I cannot understand why crystallised earths should assume such beautiful colours as most of them do. Sap-

phire, for instance, is of a celestial blue; ruby, a deep red; topaz, a brilliant yellow?

MRS. B.

Nothing is more simple than to suppose that the arrangement of their particles is such, as to transmit some of the coloured rays of light, and to reflect others, in which case the stone must appear of the colour of the rays which it reflects. But besides, it frequently happens that the colour of a stone is owing to a mixture of some metallic matter.

CAROLINE.

Pray, are the different kinds of precious stones each composed of one individual earth, or are they formed of a combination of several earths?

MRS. B.

A great variety of materials enters into the composition of most of them; not only several earths, but sometimes salts and metals. The earths, however, in their simple state, frequently form very beautiful crystals; and, indeed, it is in that state only that they can be obtained perfectly pure.

EMILY.

Is not the Derbyshire spar produced by the crystallisation of earths, in the way you have just

explained? I have been in some of the subterraneous caverns where it is found, which are similar to those you have described.

MRS. B.

Yes; but this spar is a very imperfect specimen of crystallisation; it consists of a variety of ingredients confusedly blended together, as you may judge by its opacity, and by the various colours and appearances which it exhibits.

But, in examining the earths in their most perfect and agreeable form, we must not lose sight of that state in which they are commonly found, and which, if less pleasing to the eye, is far more interesting by its utility.

All the earths are more or less endowed with alkaline properties; but there are four, barytes, magnesia, lime, and strontites, which are called *alkaline earths*, because they possess those qualities in so great a degree, as to entitle them, in most respects, to the rank of alkalies. They combine and form compound salts with acids, in the same way as alkalies; they are, like them, susceptible of a considerable degree of causticity, and are acted upon in a similar manner by chemical tests. — The remaining earths, silex and alumine, with one or two others of late discovery, are in some degree more earthy, that is to say, they possess more completely the properties common to all the earths, which

are, insipidity, dryness, unalterableness in the fire, infusibility, &c.

CAROLINE.

Yet, did you not tell us that silex, or siliceous earth, when mixed with an alkali, was fusible, and run into glass?

MRS. B.

Yes, my dear; but the characteristic properties of earths, which I have mentioned, are to be considered as belonging to them in a state of purity only; a state in which they are very seldom to be met with in nature. — Besides these general properties, each earth has its own specific characters, by which it is distinguished from any other substance. — Let us therefore review them separately.

SILEX, or SILICA, abounds in flint, sand, sandstone, agate, jasper, &c.; it forms the basis of many precious stones, and particularly of those which strike fire with steel. It is rough to the touch, scratches and wears away metals; it is acted upon by no acid but the fluoric, and is not soluble in water by any known process; but nature certainly dissolves it by means with which we are unacquainted, and thus produces a variety of siliceous crystals, and amongst these *rock crystal*, which is

the purest specimen of this earth. Silex appears to have been intended by Providence to form the solid basis of the globe, to serve as a foundation for the original mountains, and give them that hardness and durability which has enabled them to resist the various revolutions which the surface of the earth has successively undergone. From these mountains siliceous rocks have, during the course of ages, been gradually detached by torrents of water, and brought down in fragments; these, in the violence and rapidity of their descent, are sometimes crumbled to sand, and in this state form the beds of rivers and of the sea, chiefly composed of siliceous materials. Sometimes the fragments are broken without being pulverised by their fall, and assume the form of pebbles, which gradually become rounded and polished.

EMILY.

Pray what is the true colour of silex, which forms such a variety of different coloured substances? Sand is brown, flint is nearly black, and precious stones are of all colours.

MRS. B.

Pure silex, such as is found only in the chemist's laboratory, is perfectly white, and the various colours which it assumes, in the different substances you have just mentioned, proceed from

the different ingredients with which it is mixed in them.

CAROLINE.

I wonder that silex is not more valuable, since it forms the basis of so many precious stones.

MRS. B.

You must not forget that the value we set upon precious stones depends in a great measure upon the scarcity with which nature affords them; for, were those productions either common or perfectly imitable by art, they would no longer, notwithstanding their beauty, be so highly esteemed. But the real value of siliceous earth, in many of the most useful arts, is very extensive. Mixed with clay, it forms the basis of all the various kinds of earthen ware, from the most common utensils to the most refined ornaments.

EMILY.

And we must recollect its importance in the formation of glass with potash.

MRS. B.

Nor should we omit to mention, likewise, many other important uses of silex, such as being the chief ingredient of some of the most durable cements, of mortar, &c.

I said before that siliceous earth combined with no acid but the fluoric; it is for this reason that glass is liable to be attacked by that acid only, which, from its strong affinity for silex, forces that substance from its combination with the potash, and thus destroys the glass.

We will now hasten to proceed to the other earths, for I am rather apprehensive of your growing weary of this part of our subject.

CAROLINE.

Iconfess that the history of the earths is not quite so entertaining as that of the simple substances.

MRS. B.

Perhaps not; but it is absolutely indispensable that you should know something of them; for they form the basis of so many interesting and important compounds, that their total omission would throw great obscurity on our general outline of chemical science. We shall, however, review them in as cursory a manner as the subject can admit of.

ALUMINE derives its name from a compound salt called *alum*, of which it forms the basis.

CAROLINE.

But it ought to be just the contrary, Mrs. B.;

the simple body should give, instead of taking, its name from the compound.

MRS. B.

That is true; but as the compound salt was known long before its basis was discovered, it was very natural that when the earth was at length separated from the acid, it should derive its name from the compound from which it was obtained. However, to remove your scruples, we will call the salt according to the new nomenclature, *sulphat of alumine*. From this combination, alumine may be obtained in its pure state; it is then soft to the touch, makes a paste with water, and hardens in the fire. In nature, it is found chiefly in clay, which contains a considerable proportion of this earth; it is very abundant in fuller's earth, slate, and a variety of other mineral productions. There is indeed scarcely any mineral substance more useful to mankind than alumine. In the state of clay, it forms large strata of the earth, gives consistency to the soil of valleys, and of all low and damp spots, such as swamps and marshes. The beds of lakes, ponds, and springs, are almost entirely of clay; instead of allowing of the filtration of water, as sand does, it forms an impenetrable bottom, and by this means water is accumulated in the caverns of the earth, pro-

ducing those reservoirs whence springs issue, and spout out at the surface.

EMILY.

I always thought that these subterraneous reservoirs of water were bedded by some hard stone, or rock, which the water could not penetrate.

MRS. B.

That is not the case; for in the course of time water would penetrate, or wear away silex, or any other kind of stone, while it is effectually stopped by clay, or alumine.

The solid compact soils, such as are fit for corn, owe their consistence in a great measure to alumine; this earth is therefore used to improve sandy or chalky soils, which do not retain a sufficient quantity of water for the purpose of vegetation.

Alumine is the most essential ingredient in all potteries. It enters into the composition of brick, as well as that of the finest porcelain: the addition of silex and water hardens it, renders it susceptible of a degree of vitrification, and makes it perfectly fit for its various purposes.

CAROLINE.

I can scarcely conceive that brick and china should be made of the same materials.

MRS. B.

Brick consists almost entirely of baked clay; but a certain proportion of silex is essential to the formation of earthen or stone ware. In common potteries sand is used for that purpose; a more pure silex is, I believe, necessary for the composition of porcelain, as well as a finer kind of clay; and these materials are, no doubt, more carefully prepared, and curiously wrought, in the one case than in the other. Porcelain owes its beautiful semi-transparency to a commencement of vitrification.

EMILY.

But the commonest earthen-ware, though not transparent, is covered with a kind of glazing.

MRS. B.

That precaution is equally necessary for use as for beauty, as the ware would be liable to be spoiled and corroded by a variety of substances, if not covered with a coating of this kind. In porcelain it consists of enamel, which is a fine white opake glass, formed of metallic oxyds, sand, salts, and such other materials as are susceptible of vitrification. The glazing of common earthen-ware is made chiefly of oxyd of lead, or sometimes merely of salt, which, when thinly spread over earthen vessels, will, at a certain heat, run into opaque glass.

CAROLINE.

And of what nature are the colours which are used for painting porcelain?

MRS. B.

They are all composed of metallic oxyds, so that these colours, instead of receiving injury from the application of fire, are strengthened and developed by its action, which causes them to undergo different degrees of oxydation.

Alumine and silex are not only often combined by art, but they have in nature a very strong tendency to unite, and are found combined, in different proportions, in various gems and other minerals. Indeed, many of the precious stones, such as ruby, oriental sapphire, amethyst, &c. consist chiefly of alumine.

We may now proceed to the alkaline earths. I shall say but a few words on BARYTES, as it is hardly ever used, except in chemical laboratories. It is remarkable for its great weight, and its strong alkaline properties, such as destroying animal substances, turning green some blue vegetable colours, and showing a powerful attraction for acids; this last property it possesses to such a degree, particularly with regard to the sulphuric acid, that it will always detect its presence in any substance or combination whatever, by immediately uniting with it, and forming a sulphat of barytes. This

renders it a very valuable chemical test. It is found pretty abundantly in nature in the state of carbonat, from which the pure earth can be easily separated.

The next earth we have to consider is LIME. This is a substance of too great and general importance to be passed over so slightly as the last.

Lime is strongly alkaline. In nature it is not met with in its simple state, as its affinity for water and carbonic acid is so great, that it is always found combined with these substances, with which it forms the common lime-stone; but it is separated in the kiln from these ingredients, which are volatilised whenever a sufficient degree of heat is applied.

EMILY.

Pure lime, then, is nothing but lime-stone, which has been deprived, in the kiln, of its water and carbonic acid?

MRS. B.

Precisely: in this state it is called *quick-lime*, and it is so caustic, that it is capable of decomposing the dead bodies of animals very rapidly, without their undergoing the process of putrefaction. —I have here some quick lime, which is kept carefully corked up in a bottle to prevent the

access of air; for were it at all exposed to the atmosphere, it would absorb both moisture and carbonic acid gas from it, and be soon slaked. Here is also some lime-stone — we shall pour a little water on each, and observe the effects that result from it.

CAROLINE.

How the quick-lime hisses! It is become excessively hot! — It swells, and now it bursts and crambles to powder, while the water appears to produce no kind of alteration on the lime-stone.

MRS. B.

Because the lime-stone is already saturated with water, whilst the quick-lime, which has been deprived of it in the kiln, combines with it with very great avidity, and produces this prodigious disengagement of heat, the cause of which I formerly explained to you; do you recollect it?

EMILY.

Yes; you said that the heat did not proceed from the lime, but from the water which was *solidified*, and thus parted with its heat of liquidity.

MRS. B.

Very well. If we continue to add successive quantities of water to the lime after being slaked

and crumbled as you see, it will then gradually be diffused in the water, till it will at length be dissolved in it, and entirely disappear; but for this purpose it requires no less than 700 times its weight of water. This solution is called *lime-water.*

CAROLINE.

How very small, then, is the proportion of lime dissolved!

MRS. B.

Barytes is still of more difficult solution; it dissolves only in 900 times its weight of water: but is much more soluble in the state of crystals. The liquid contained in this bottle is lime-water; it is often used as a medicine, chiefly, I believe, for the purpose of combining with, and neutralising, the superabundant acid which it meets with in the stomach.

EMILY.

I am surprised that it is so perfectly clear; it does not at all partake of the whiteness of the lime.

MRS. B.

Have you forgotten that, in solutions, the solid body is so minutely subdivided by the fluid as to become invisible, and therefore will not in the least degree impair the transparency of the solvent?

I said that the attraction of lime for carbonic acid was so strong, that it would absorb it from the atmosphere. We may see this effect by exposing a glass of lime-water to the air; the lime will then separate from the water, combine with the carbonic acid, and re-appear on the surface in the form of a white film, which is carbonat of lime, commonly called *chalk*.

CAROLINE.

Chalk is, then, a compound salt! I never should have supposed that those immense beds of chalk, that we see in many parts of the country, were a salt. — Now, the white film begins to appear on the surface of the water: but it is far from resembling hard solid chalk.

MRS. B.

That is owing to its state of extreme division; in a little time it will collect into a more compact mass, and subside at the bottom of the glass.

If you breathe into lime-water, the carbonic acid, which is mixed with the air that you expire, will produce the same effect. It is an experiment very easily made; — I shall pour some lime-water into this glass tube, and, by breathing repeatedly into it, you will soon perceive a precipitation of chalk —

EMILY.

I see already a small white cloud formed.

MRS. B.

It is composed of minute particles of chalk; at present it floats in the water, but it will soon subside.

Carbonat of lime, or chalk, you see, is insoluble in water, since the lime which was dissolved re-appears when converted into chalk; but you must take notice of a very singular circumstance, which is, that chalk is soluble in water impregnated with carbonic acid.

CAROLINE.

It is very curious, indeed, that carbonic acid gas should render lime soluble in one instance, and insoluble in the other!

MRS. B.

I have here a bottle of Seltzer water, which, you know, is strongly impregnated with carbonic acid:—let us pour a little of it into a glass of lime-water. You see that it immediately forms a precipitation of carbonat of lime?

EMILY.

Yes, a white cloud appears.

MRS. B.

I shall now pour an additional quantity of the Seltzer water into the lime-water —

EMILY.

How-singular! The cloud is re-dissolved, and the liquid is again transparent.

MRS. B.

All the mystery depends upon this circumstance, that carbonat of lime is soluble in carbonic acid, whilst it is insoluble in water; the first quantity of carbonic acid, therefore, which I introduced into the lime-water, was employed in forming the carbonat of lime, which remained visible, until an additional quantity of carbonic acid dissolved it. Thus, you see, when the lime and carbonic acid are in proper proportions to form chalk, the white cloud appears, but when the acid predominates, the chalk is no sooner formed than it is dissolved.

CAROLINE.

That is now the case; but let us try whether a further addition of lime-water will again precipitate the chalk.

EMILY.

It does, indeed! The cloud re-appears, because,

I suppose, there is now no more of the carbonic acid than is necessary to form chalk; and, in order to dissolve the chalk, a superabundance of acid is required.

MRS. B.

We have, I think, carried this experiment far enough; every repetition would but exhibit the same appearances.

Lime combines with most of the acids, to which the carbonic (as being the weakest) readily yields it; but these combinations we shall have an opportunity of noticing more particularly hereafter. It unites with phosphorus, and with sulphur, in their simple state; in short, of all the earths, lime is that which nature employs most frequently, and most abundantly, in its innumerable combinations. It is the basis of all calcareous earths and stones; we find it likewise in the animal and the vegetable creations.

EMILY.

And in the arts is not lime of very great utility?

MRS. B.

Scarcely any substance more so; you know that it is a most essential requisite in building, as it constitutes the basis of all cements, such as mortar, stucco, plaster, &c.

Lime is also of infinite importance in agriculture; it lightens and warms soils that are too cold and compact, in consequence of too great a proportion of clay. — But it would be endless to enumerate the various purposes for which it is employed; and you know enough of it to form some idea of its importance; we shall, therefore, now proceed to the third alkaline earth, MAGNESIA.

CAROLINE.

I am already pretty well acquainted with that earth; it is a medicine.

MRS. B.

It is in the state of carbonat that magnesia is usually employed medicinally; it then differs but little in appearance from its simple form, which is that of a very fine light white powder. It dissolves in 2000 times its weight of water, but forms with acids extremely soluble salts. It has not so great an attraction for acids as lime, and consequently yields them to the latter. It is found in a great variety of mineral combinations, such as slate, mica, amianthus, and more particularly in a certain lime-stone, which has lately been discovered by Mr. Tennant to contain it in very great quantities. It does not attract and solidify water, like lime: but when mixed with water and exposed to the atmosphere, it slowly absorbs

carbonic acid from the latter, and thus loses its causticity. Its chief use in medicine is, like that of lime, derived from its readiness to combine with, and neutralise, the acid which it meets with in the stomach.

EMILY.

Yet, you said that it was taken in the state of carbonat, in which case it has already combined with an acid?

MRS. B.

Yes; but the carbonic is the last of all the acids in the order of affinities; it will therefore yield the magnesia to any of the others. It is, however, frequently taken in its caustic state as a remedy for flatulence. Combined with sulphuric acid, magnesia forms another and more powerful medicine, commonly called *Epsom salt.*

CAROLINE.

And properly, *sulphat of magnesia,* I suppose? Pray why was it ever called Epsom salt?

MRS. B.

Because there is a spring in the neighbourhood of Epsom which contains this salt in great abundance.

The last alkaline earth which we have to mention is STRONTIAN, or STRONTITES, discovered by

Dr. Hope a few years ago. It so strongly resembles barytes in its properties, and is so sparingly found in nature, and of so little use in the arts, that it will not be necessary to enter into any particulars respecting it. One of the remarkable characteristic properties of strontites is, that its salts, when dissolved in spirit of wine, tinge the flame of a deep red, or blood colour.

CONVERSATION XVI.

ON ACIDS.

MRS. B.

We may now proceed to the acids. Of the metallic oxyds, you have already acquired some general notions. This subject, though highly interesting in its details, is not of sufficient importance to our concise view of chemistry, to be particularly treated of; but it is absolutely necessary that you should be better acquainted with the acids, and likewise with their combinations with the alkalies, which form the triple compounds called NEUTRAL SALTS.

The class of acids is characterised by very distinct properties. They all change blue vegetable infusions to a red colour: they are all more or less sour to the taste; and have a general tendency to combine with the earths, alkalies, and metallic oxyds.

You have, I believe, a clear idea of the nomenclature by which the base (or radical) of the acid, and the various degrees of acidification, are expressed?

EMILY.

Yes, I think so; the acid is distinguished by the

name of its base, and its degree of oxydation, that is, the quantity of oxygen it contains, by the termination of that name in *ous* or *ic*; thus sulphureous acid is that formed by the smallest proportion of oxygen combined with sulphur; sulphur*ic* acid that which results from the combination of sulphur with the greatest quantity of oxygen.

MRS. B.

A still greater latitude may, in many cases, be allowed to the proportions of oxygen that can be combined with acidificiable radicals; for several of these radicals are susceptible of uniting with a quantity of oxygen so small as to be insufficient to give them the properties of acids; in these cases, therefore, they are converted into oxyds. Such is sulphur, which by exposure to the atmosphere with a degree of heat inadequate to produce inflammation, absorbs a small proportion of oxygen, which colours it red or brown. This, therefore, is the first degree of oxygenation of sulphur; the 2d converts it into sulphur*ous* acid; the 3d into the sulphur*ic* acid; and 4thly, if it was found capable of combining with a still larger proportion of oxygen, it would then be termed *super-oxygenated sulphuric acid.*

EMILY.

Are these various degrees of oxygenation common to all the acids?

MRS. B.

No; they vary much in this respect: some are susceptible of only one degree of oxygenation; others, of two, or three; there are but very few that will admit of more.

CAROLINE.

The modern nomenclature must be of immense advantage in pointing out so easily the nature of the acids, and their various degrees of oxygenation.

MRS. B.

Till lately many of the acids had not been decomposed; but analogy afforded so strong a proof of their compound nature, that I never could reconcile myself to classing them with the simple bodies, though this division has been adopted by several chemical writers. At present there are only the muriatic and the fluoric acids, which have not had their bases distinctly separated.

CAROLINE.

We have heard of a great variety of acids; pray how many are there in all?

MRS. B.

I believe there are reckoned at present thirty-four, and their number is constantly increasing, as the science improves; but the most important,

and those to which we shall almost entirely confine our attention, are but few. I shall, however, give you a general view of the whole; and then we shall more particularly examine those that are the most essential.

This class of bodies was formerly divided into mineral, vegetable, and animal acids, according to the substances from which they were commonly obtained.

CAROLINE.

That, I should think, must have been an excellent arrangement; why was it altered?

MRS. B.

Because in many cases it produced confusion. In which class, for instance, would you place carbonic acid?

CAROLINE.

Now I see the difficulty. I should be at a loss where to place it, as you have told us that it exists in the animal, vegetable, and mineral kingdoms.

EMILY.

There would be the same objection with respect to phosphoric acid, which, though obtained chiefly from bones, can also, you said, be found in small quantities in stones, and likewise in some plants.

MRS. B.

You see, therefore, the propriety of changing

this mode of classification. These objections do not exist in the present nomenclature; for the composition and nature of each individual acid is in some degree pointed out, instead of the class of bodies from which it is extracted; and, with regard to the more general division of acids, they are classed under these three heads:

First, Acids of known or supposed simple bases, which are formed by the union of these bases with oxygen. They are the following:

The *Sulphuric*	Acids, of known and simple bases.
Carbonic	
Nitric	
Phosphoric	
Arsenical	
Tungstenic	
Molybdenic	
Boracic	
Fluoric	
Muriatic	

This class comprehends the most anciently known and most important acids. The sulphuric, nitric, and muriatic were formerly, and are still frequently, called *mineral acids.*

2dly, Acids that have double or binary radicals, and which consequently consist of triple combinations. These are the vegetable acids, whose common radical is a compound of hydrogen and carbon.

CAROLINE.

But if the basis of all the vegetable acids be the same, it should form but one acid; it may indeed combine with different proportions of oxygen, but the nature of the acid must be the same.

MRS. B.

The only difference that exists in the basis of vegetable acids, is the various proportions of hydrogen and carbon from which they are severally composed. But this is enough to produce a number of acids apparently very dissimilar. That they do not, however, differ essentially, is proved by their susceptibility of being converted into each other, by the addition or subtraction of a portion of hydrogen or of carbon. The names of these acids are,

The *Acetic*
Oxalic
Tartarous
Citric
Malic
Gallic
Mucous
Benzoic
Succinic
Camphoric
Suberic

Acids, of double bases, being of vegetable origin.

The 3d class of acids consists of those which have triple radicals, and are therefore of a still more compound nature. This class comprehends the animal acids, which are,

The *Lactic* *Prussic* *Formic* *Bombic* *Sebacic* *Zoonic* *Lithic*	Acids, of triple bases, or animal acids.

I have given you this summary account or enumeration of the acids, as you may find it more satisfactory to have at once an outline or a general notion of the extent of the subject; but we shall now confine ourselves to the first class, which requires our more immediate attention; and defer the few remarks which we shall have to make on the others, till we treat of the chemistry of the animal and vegetable kingdoms.

The acids of simple and known radicals are all capable of being decomposed by combustible bodies, to which they yield their oxygen. If, for instance, I pour a drop of sulphuric acid on this piece of iron, it will produce a spot of rust, you know what that is?

CAROLINE.

Yes; it is an oxyd, formed by the oxygen of the acid combining with the iron.

MRS. B.

In this case you see the sulphur deposits the oxygen by which it was acidified on the metal. And again, if we pour some acid on a compound combustible substance, (we shall try it on this piece of wood,) it will combine with one or more of the constituents of that substance, and occasion a decomposition.

EMILY.

It has changed the colour of the wood to black. How is that?

MRS. B.

The oxygen deposited by the acid has burnt it; you know that wood in burning becomes black before it is reduced to ashes. Whether it derives the oxygen which burns it from the atmosphere, or from any other source, the chemical effect on the wood is the same. In the case of real combustion, wood becomes black, because it is reduced to the state of charcoal by the evaporation of its other constituents. But can you tell me the reason why wood turns black when burnt by the application of an acid?

CAROLINE.

First, tell me what are the ingredients of wood?

MRS. B.

Hydrogen and carbon are the chief constitutes of wood, as of all other vegetable substances.

CAROLINE.

Well, then, I suppose that the oxygen of the acid combines with the hydrogen of the wood, to form water; and that the carbon of the wood, remaining alone, appears of its usual black colour.

MRS. B.

Very well indeed, my dear; that is certainly the most plausible explanation.

EMILY.

Would not this be a good method of making charcoal?

MRS. B.

It would be an extremely expensive, and, I believe, very imperfect method; for the action of the acid on the wood, and the heat produced by it, are far from sufficient to deprive the wood of all its evaporable parts.

CAROLINE.

What is the reason that vinegar, lemon, and the acid of fruits, do not produce this effect on wood?

MRS. B.

They are vegetable acids, whose bases are composed of hydrogen and carbon; the oxygen, therefore, will not be disposed to quit this radical, where it is already united with hydrogen. The strongest of these may, perhaps, yield a little of their oxygen to the wood, and produce a stain upon it; but the carbon will not be sufficiently uncovered to assume its black colour. Indeed, the several mineral acids themselves possess this power of charing wood in very different degrees.

EMILY.

Cannot vegetable acids be decomposed, by any combustibles?

MRS. B.

No; because their radical is composed of two substances which have a greater attraction for oxygen than any known body.

CAROLINE.

And are those strong acids, which burn and decompose wood, capable of producing similar effects on the skin and flesh of animals?

MRS. B.

Yes; all the mineral acids, and one of them more especially, possess powerful caustic qualities. They actually corrode and destroy the

skin and flesh; but they do not produce upon these exactly the same alteration they do on wood, probably because there is a great proportion of nitrogen and other substances in animal matter, which prevents the separation of carbon from being so conspicuous.

CONVERSATION XVII.

OF THE SULPHURIC AND PHOSPHORIC ACIDS; OR THE COMBINATIONS OF OXYGEN WITH SULPHUR AND PHOSPHORUS; AND OF THE SULPHATS AND PHOSPHATS.

MRS. B.

In addition to the general survey which we have taken of acids, I think you will find it interesting to examine individually a few of the most important of them, and likewise some of their principal combinations with the alkalies, alkaline earths, and metals. The first of the acids, in point of importance, is the SULPHURIC, formerly called *oil of vitriol.*

CAROLINE.

I have known it a long time by that name, but had no idea that it was the same fluid as sulphuric acid. What resemblance or connection can there be between oil of vitriol and this acid?

MRS. B.

Vitriol is the common name for sulphat of iron, a salt which is formed by the combination of sulphuric acid and iron; the sulphuric acid was for-

merly obtained by distillation from this salt, and it very naturally received its name from the substance which afforded it.

CAROLINE.

But it is still usually called oil of vitriol?

MRS. B.

Yes; a sufficient length of time has not yet elapsed, since the invention of the new nomenclature, for it to be generally disseminated; but, as it is adopted by all scientific chemists, there is every reason to suppose that it will gradually become universal. When I received this bottle from the chemists, *oil of vitriol* was inscribed on the label; but, as I knew you were very punctilious in regard to the nomenclature, I changed it, and substituted the words *sulphuric acid.*

EMILY.

This acid has neither colour nor smell, but it appears much thicker than water.

MRS. B.

It is nearly twice as heavy as water, and has, you see, an oily consistence.

CAROLINE.

And it is probably from this circumstance that

it has been called an oil, for it can have no real claim to that name, as it does not contain either hydrogen or carbon, which are the essential constituents of oil.

MRS. B.

Certainly; and therefore it would be the more absurd to retain a name which owed its origin to such a mistaken analogy.

Sulphuric acid, in its purest state, would probably be a concrete substance, but its attraction for water is such, that it is impossible to obtain that acid perfectly free from it; it is, therefore, always seen in a liquid form, such as you here find it. One of the most striking properties of sulphuric acid is that of evolving a considerable quantity of heat when mixed with water; this I have already shown you.

EMILY.

Yes, I recollect it; but what was the degree of heat produced by that mixture?

MRS. B.

The thermometer may be raised by it to 300 degrees, which is considerably above the temperature of boiling water.

CAROLINE.

Then water might be made to boil in that mixture?

MRS. B.

Nothing more easy, provided that you employ sufficient quantities of acid and of water, and in the due proportions. The greatest heat is produced by a mixture of one part of water to four of the acid: we shall make a mixture of these proportions, and immerse in it this thin glass tube, which is full of water.

CAROLINE.

The vessel feels extremely hot, but the water does not boil yet.

MRS. B.

You must allow some time for the heat to penetrate the tube, and raise the temperature of the water to the boiling point —

CAROLINE.

Now it boils — and with increasing violence.

MRS. B.

But it will not continue boiling long; for the mixture gives out heat only while the particles of the water and the acid are mutually penetrating each other: as soon as the new arrangement of those particles is effected, the mixture will gradually cool, and the water return to its former temperature.

You have seen the manner in which sulphuric

acid decomposes all combustible substances, whether animal, vegetable, or mineral, and burns them by means of its oxygen?

CAROLINE.

I have very unintentionally repeated the experiment on my gown, by letting a drop of the acid fall upon it, and it has made a stain, which, I suppose, will never wash out.

MRS. B.

No, certainly; for before you can put it into water, the spot will become a hole, as the acid has literally burnt the muslin.

CAROLINE.

So it has indeed! Well, I will fasten the stopper, and put the bottle away, for it is a dangerous subtance. — Oh, now I have done worse still, for I have spilt some on my hand!

MRS. B.

It is then burned, as well as your gown, for you know that oxygen destroys animal as well as vegetable matters; and, as far as the decomposition of the skin of your finger is effected, there is no remedy; but by washing it immediately in water, you will dilute the acid, and prevent any further injury.

CAROLINE.

It feels extremely hot, I assure you.

MRS. B.

You have now learned, by experience, how cautiously this acid must be used. You will soon become acquainted with another acid, the nitric, which, though it produces less heat on the skin, destroys it still quicker, and makes upon it an indelible stain. You should never handle any substances of this kind, without previously dipping your fingers in water, which will weaken their caustic effects. But, since you will not repeat the experiment, I must put in the stopper, for the acid attracts the moisture from the atmosphere, which would destroy its strength and purity.

EMILY.

Pray, how can sulphuric acid be extracted from sulphat of iron by distillation?

MRS. B.

The process of distillation, you know, consists in separating substances from one another by means of their different degrees of volatility, and by the introduction of a new chemical agent, caloric. Thus, if sulphat of iron be exposed in a retort to a proper degree of heat, it will be decomposed, and the sulphuric acid will be volatilised.

EMILY.

But now that the process of forming acids by the combustion of their radicals is known, why should not this method be used for making sulphuric acid?

MRS. B.

This is actually done in most manufactures; but the usual method of preparing sulphuric acid does not consist in burning the sulphur in oxygen gas (as we formerly did by the way of experiment), but in heating it together with another substance, nitre, which yields oxygen in sufficient abundance to render the combustion in common air rapid and complete.

CAROLINE.

This substance, then, answers the same purpose as oxygen gas?

MRS. B.

Exactly. In manufactures the combustion is performed in a leaden chamber, with water at the bottom, to receive the vapour and assist its condensation. The combustion is, however, never so perfect but that a quantity of *sulphureous* acid is formed at the same time; for you recollect that the sulphureous acid, according to the chemical nomenclature, differs from the sulphuric only by containing less oxygen.

From its own powerful properties, and from the various combinations into which it enters, sul-

phuric acid is of great importance in many of the arts.

It is used also in medicine in a state of great dilution; for were it taken internally, in a concentrated state, it would prove a most dangerous poison.

CAROLINE.

I am sure it would burn the throat and stomach.

MRS. B.

Can you think of any thing that would prove an antidote to this poison?

CAROLINE.

A large draught of water to dilute it.

MRS. B.

That would certainly weaken the caustic power of the acid, but it would increase the heat to an intolerable degree. Do you recollect nothing that would destroy its deleterious properties more effectually?

EMILY.

An alkali might, by combining with it; but, then, a pure alkali is itself a poison, on account of its causticity.

MRS. B.

There is no necessity that the alkali should be

caustic. Soap, in which it is combined with oil; or magnesia, either in the state of carbonat, or mixed with water, would prove the best antidotes.

EMILY.

In those cases then, I suppose, the potash and the magnesia would quit their combinations to form salts with the sulphuric acid?

MRS. B.

Precisely.

We may now make a few observations on the sulphure*ous* acid, which we have found to be the product of sulphur slowly and imperfectly burnt. This acid is distinguished by its pungent smell, and its gaseous form.

CAROLINE.

Its aëriform state is, I suppose, owing to the smaller proportion of oxygen, which renders it lighter than sulphur*ic* acid?

MRS. B.

Probably; for by adding oxygen to the weaker acid, it may be converted into the stronger kind. But this change of state may also be connected with a change of affinity with regard to caloric.

EMILY.

And may sulphureous acid be obtained from sulphuric acid by a diminution of oxygen?

MRS. B.

Yes; it can be done by bringing any combustible substance in contact with the acid. This decomposition is most easily performed by some of the metals; these absorb a portion of the oxygen from the sulphuric acid, which is thus converted into the sulphureous, and flies off in its gaseous form.

CAROLINE.

And cannot the sulphureous acid itself be decomposed and reduced to sulphur?

MRS. B.

Yes; if this gas be heated in contact with charcoal, the oxygen of the gas will combine with it, and the pure sulphur is regenerated.

Sulphureous acid is readily absorbed by water; and in this liquid state it is found particularly useful in bleaching linen and woollen cloths, and is much used in manufactures for those purposes. I can show you its effect in destroying colours, by taking out vegetable stains — I think I see a spot on your gown, Emily, on which we may try the experiment.

EMILY.

It is the stain of mulberries; but I shall be almost afraid of exposing my gown to the experiment, after seeing the effect which the sulphuric acid produced on that of Caroline —

MRS. B.

There is no such danger from the sulphureous; but the experiment must be made with great caution, for during the formation of sulphureous acid by combustion, there is always some sulphuric produced.

CAROLINE.

But where is your sulphureous acid?

MRS. B.

We may easily prepare some ourselves, simply by burning a match; we must first wet the stain with water, and now hold it in this way, at a little distance, over the lighted match: the vapour that arises from it is sulphureous acid, and the stain, you see, gradually disappears.

EMILY.

I have frequently taken out stains by this means, without understanding the nature of the process. But why is it necessary to wet the stain before it is exposed to the acid fumes?

MRS. B.

The moisture attracts and absorbs the sulphureous acid; and it serves likewise to dilute any particles of sulphuric acid which might injure the linen.

Sulphur is susceptible of a third combination

with oxygen, in which the proportion of the latter is too small to render the sulphur acid. It acquires this slight oxygenation by mere exposure to the atmosphere, without any elevation of temperature: in this case, the sulphur does not change its natural form, but is only discoloured, being changed to red or brown; and in this state it is an oxyd of sulphur.

Before we take leave of the sulphuric acid, we shall say a few words of its principal combinations. It unites with all the alkalies, alkaline earths and metals, to form compound salts.

CAROLINE.

Pray, give me leave to interrupt you for a moment: you have never mentioned any other salts than the compound or neutral salts; is there no other kind?

MRS. B.

The term *salt* has been used, from time immemorial, as a kind of general name for any substance that has savour, odour, is soluble in water, and crystallisable, whether it be of an acid, an alkaline, or compound nature; but the compound salts alone retain that appellation in modern chemistry.

The most important of the salts, formed by the combinations of the sulphuric acid, are, first, *sulphat of potash*, formerly called *sal polychrest*: this

is a very bitter salt, much used in medicine; it is found in the ashes of most vegetables, but it may be prepared artificially by the immediate combination of sulphuric acid and potash. This salt is easily soluble in boiling water. Solubility is, indeed, a property common to all salts; and they always produce cold in melting.

EMILY.

That must be owing to the caloric which they absorb in passing from a solid to a fluid form.

MRS. B.

That is, certainly, the most probable explanation.

Sulphat of soda, commonly called Glauber's salt, is another medicinal salt, which is still more bitter than the preceding. We must prepare some of these compounds, that you may observe the phenomena which take place during their formation. We need only pour some sulphuric acid over the soda which I have put into this glass.

CAROLINE.

What an amazing heat is disengaged! — I thought you said that cold was produced by the melting of salts?

MRS. B.

But you must observe that we are now *making*,

not *melting* a salt. Heat is disengaged during the formation of compound salts, and a faint light is also emitted, which may sometimes be perceived in the dark.

EMILY.

And is this heat and light produced by the union of the opposite electricities of the alkali and the acid?

MRS. B.

No doubt it is, if that theory be true.

CAROLINE.

The union of an acid and an alkali is then an actual combustion?

MRS. B.

Not precisely, though there is certainly much analogy in these processes.

CAROLINE.

Will this sulphat of soda become solid?

MRS. B.

We have not, I suppose, mixed the acid and the alkali in the exact proportions that are required for the formation of the salt, otherwise the mixture would have been almost immediately changed to a solid mass; but, in order to obtain it in crystals, as you see it in this bottle, it would be necessary first to dilute it with water, and after-

wards to evaporate the water, during which operation the salt would gradually crystallise.

CAROLINE.

But of what use is the addition of water, if it is afterwards to be evaporated?

MRS. B.

When suspended in water, the acid and the alkali are more at liberty to act on each other, their union is more complete, and the salt assumes the regular form of crystals during the slow evaporation of its solvent.

Sulphat of soda liquefies by heat, and effloresces in the air.

EMILY.

Pray what is the meaning of the word *effloresces?* I do not recollect your having mentioned it before.

MRS. B.

A salt is said to effloresce when it loses its water of crystallisation on being exposed to the atmosphere, and is thus gradually converted into a dry powder: you may observe that these crystals of sulphat of soda are far from possessing the transparency which belongs to their crystalline state; they are covered with a white powder, occasioned by their having been exposed to the atmosphere, which has deprived their surface of its lustre, by

absorbing its water of crystallisation. Salts are, in general, either *efflorescent* or *deliquescent*: this latter property is precisely the reverse of the former; that is to say, deliquescent salts absorb water from the atmosphere, and are moistened and gradually melted by it. Muriat of lime is an instance of great deliquescence.

EMILY.

But are there no salts that have the same degree of attraction for water as the atmosphere, and that will consequently not be affected by it?

MRS. B.

Yes; there are many such salts, as, for instance, common salt, sulphat of magnesia, and a variety of others.

Sulphat of lime is very frequently met with in nature, and constitutes the well-known substance called *gypsum*, or *plaster of Paris.*

Sulphat of magnesia, commonly called *Epsom salt*, is another very bitter medicine, which is obtained from sea-water and from several springs, or may be prepared by the direct combination of its ingredients.

We have formerly mentioned *sulphat of alumine* as constituting the common *alum*; it is found in nature chiefly in the neighbourhood of volcanoes, and is particularly useful in the arts, from its

strong astringent qualities. It is chiefly employed by dyers and calico-printers, to fix colours; and is used also in the manufacture of some kinds of leather.

Sulphuric acid combines also with the metals.

CAROLINE.

One of these combinations, *Sulphat of iron*, we are already well acquainted with.

MRS. B.

That is the most important metallic salt formed by sulphuric acid, and the only one that we shall here notice. It is of great use in the arts; and, in medicine, it affords a very valuable tonic: it is of this salt that most of those preparations called *steel medicines* are composed.

CAROLINE.

But does any carbon enter into these compositions to form steel?

MRS. B.

Not an atom: they are, therefore, very improperly called steel: but it is the vulgar appellation, and medical men themselves often comply with the general custom.

Sulphat of iron may be prepared, as you have seen, by dissolving iron in sulphuric acid; but it

is generally obtained from the natural production called *Pyrites*, which being a sulphuret of iron, requires only exposure to the atmosphere to be oxydated, in order to form the salt; this, therefore, is much the most easy way of procuring it on a large scale.

EMILY.

I am surprised to find that both acids and compound salts are generally obtained from their various combinations, rather than from the immediate union of their ingredients.

MRS. B.

Were the simple bodies always at hand, their combinations would naturally be the most convenient method of forming compounds; but you must consider that, in most instances, there is great difficulty and expense in obtaining the simple ingredients from their combinations; it is, therefore, often more expedient to procure compounds from the decomposition of other compounds. But, to return to the sulphat of iron. — There is a certain vegetable acid called *Gallic acid*, which has the remarkable property of precipitating this salt black — I shall pour a few drops of the gallic acid into this solution of sulphat of iron —

CAROLINE.

It is become as black as ink!

MRS. B.

And it is ink in reality. Common writing ink is a precipitate of sulphat of iron by gallic acid; the black colour is owing to the formation of gallat of iron, which being insoluble, remains suspended in the fluid.

This acid has also the property of altering the colour of iron in its metallic state. You may frequently see its effect on the blade of a knife, that has been used to cut certain kinds of fruits.

CAROLINE.

True; and that is, perhaps, the reason that a silver knife is preferred to cut fruits; the gallic acid, I suppose, does not act upon silver. — Is this acid found in all fruits?

MRS. B.

It is contained, more or less, in the rind of most fruits and roots, especially the radish, which, if scraped with a steel or iron knife, has its bright red colour changed to a deep purple, the knife being at the same time blackened. But the vegetable substance in which the gallic acid most abounds is *nutgall*, a kind of excrescence that grows on oaks, and from which the acid is commonly obtained for its various purposes.

MRS. B.

We now come to the PHOSPHORIC and PHOSPHOROUS ACIDS. In treating of phosphorus, you have seen how these acids may be obtained from it by combustion?

EMILY.

Yes: but I should be much surprised if it was the usual method of obtaining them, since it is so very difficult to procure phosphorus in its pure state.

MRS. B.

You are right, my dear; the phosphoric acid, for general purposes, is extracted from bones, in which it is contained in the state of phosphat of lime; from this salt the phosphoric acid is separated by means of the sulphuric, which combines with the lime. In its pure state, phosphoric acid is either liquid or solid, according to its degree of concentration.

Among the salts formed by this acid, *phosphat of lime* is the only one that affords much interest; and this, we have already observed, constitutes the basis of all bones. It is also found in very small quantities in some vegetables.

CONVERSATION XVIII.

OF THE NITRIC AND CARBONIC ACIDS: OR THE COMBINATIONS OF OXYGEN WITH NITROGEN AND CARBON; AND OF THE NITRATS AND CARBONATS.

MRS. B.

I AM almost afraid of introducing the subject of the NITRIC ACID, as I am sure that I shall be blamed by Caroline for not having made her acquainted with it before.

CAROLINE.

Why so, Mrs. B.?

MRS. B.

Because you have long known its radical, which is nitrogen or azote; and in treating of that element, I did not even hint that it was the basis of an acid.

CAROLINE.

And what could be your reason for not mentioning this acid sooner?

MRS. B.

I do not know whether you will think the reason

sufficiently good to acquit me; but the omission, I assure you, did not proceed from negligence. You may recollect that nitrogen was one of the first simple bodies which we examined; you were then ignorant of the theory of combustion, which I believe was, for the first time, mentioned in that lesson; and therefore it would have been in vain, at that time, to have attempted to explain the nature and formation of acids.

CAROLINE.

I wonder, however, that it never occurred to us to enquire whether nitrogen could be acidified; for, as we knew it was classed among the combustible bodies, it was natural to suppose that it might produce an acid.

MRS. B.

That is not a necessary consequence: for it might combine with oxygen only in the degree requisite to form an oxyd. But you will find that nitrogen is susceptible of various degrees of oxygenation, some of which convert it merely into an oxyd, and others give it all the acid properties.

The acids, resulting from the combination of oxygen and nitrogen, are called the NITROUS and NITRIC acids. We will begin with the NITRIC, in which nitrogen is in the highest state of oxygenation. This acid naturally exists in the form of

gas; but is so very soluble in water, and has so great an affinity for it, that one grain of water will absorb and condense ten grains of acid gas, and form the limpid fluid which you see in this bottle.

CAROLINE.

What a strong offensive smell it has!

MRS. B.

This acid contains a greater abundance of oxygen than any other, but it retains it with very little force.

EMILY.

Then it must be a powerful caustic, both from the facility with which it parts with its oxygen, and the quantity which it affords?

MRS. B.

Very well, Emily; both cause and effect are exactly such as you describe: nitric acid burns and destroys all kinds of organized matter. It even sets fire to some of the most combustible substances. — We shall pour a little of it over this piece of dry warm charcoal — you see it inflames it immediately; it would do the same with oil of turpentine, phosphorus, and several other very combustible bodies. This shows you how easily this acid is decomposed by combustible bodies,

since these effects must depend upon the absorption of its oxygen.

Nitric acid has been used in the arts from time immemorial, but it is only within these twenty-five years that its chemical nature has been ascertained. The celebrated Mr. Cavendish discovered that it consisted of about 10 parts of nitrogen and 25 of oxygen.* These principles, in their gaseous state, combine at a high temperature; and this may be effected by repeatedly passing the electrical spark through a mixture of the two gases.

EMILY.

The nitrogen and oxygen gases, of which the atmosphere is composed, do not combine, I suppose, because their temperature is not sufficiently elevated?

CAROLINE.

But in a thunder-storm, when the lightning repeatedly passes through them, may it not produce nitric acid? We should be in a strange situation, if a violent storm should at once convert the atmosphere into nitric acid.

MRS. B.

There is no danger of it, my dear; the lightning can affect but a very small portion of the

* The proportion stated by Sir H. Davy, in his Chemical Researches, is as 1 to 2,389.

atmosphere, and though it were occasionally to produce a little nitric acid, yet this never could happen to such an extent as to be perceivable.

EMILY.

But how could the nitric acid be known, and used, before the method of combining its constituents was discovered?

MRS. B.

Before that period the nitric acid was obtained, and it is indeed still extracted, for the common purposes of art, from the compound salt which it forms with potash, commonly called *nitre*.

CAROLINE.

Why is it so called? Pray, Mrs. B., let these old unmeaning names be entirely given up, by us at least; and let us call this salt *nitrat of potash*.

MRS. B.

With all my heart; but it is necessary that I should, at least, mention the old names, and more especially those which are yet in common use; otherwise, when you meet with them, you would not be able to understand their meaning.

EMILY.

And how is the acid obtained from this salt?

MRS. B.

By the intervention of sulphuric acid, which combines with the potash, and sets the nitric acid at liberty. This I can easily show you, by mixing some nitrat of potash and sulphuric acid in this retort, and heating it over a lamp; the nitric acid will come over in the form of vapour, which we shall collect in a glass bell. This acid, diluted in water, is commonly called *aqua fortis*, if Caroline will allow me to mention that name.

CAROLINE.

I have often heard that aqua fortis will dissolve almost all metals; it is no doubt because it yields its oxygen so easily.

MRS. B.

Yes; and from this powerful solvent property, it derived the name of aqua fortis, or strong water. Do you not recollect that we oxydated, and afterwards dissolved, some copper in this acid?

EMILY.

If I remember right, the nitrat of copper was the first instance you gave us of a compound salt.

CAROLINE.

Can the nitric acid be completely decomposed and converted into nitrogen and oxygen?

EMILY.

That cannot be the case, Caroline: since the acid can be decomposed only by the combination of its constituents with other bodies.

MRS. B.

True; but caloric is sufficient for this purpose. By making the acid pass through a red hot porcelain tube, it is decomposed; the nitrogen and oxygen regain the caloric which they had lost in combining, and are thus both restored to their gaseous state.

The nitric acid may also be partly decomposed, and is by this means converted into NITROUS ACID.

CAROLINE.

This conversion must be easily effected, as the oxygen is so slightly combined with the nitrogen.

MRS. B.

The partial decomposition of nitric acid is readily effected by most metals; but it is sufficient to expose the nitric acid to a very strong light to make it give out oxygen gas, and thus be converted into nitrous acid. Of this acid there are various degrees, according to the proportions of oxygen which it contains; the strongest, and that into which the nitric is first converted, is of a yellow colour, as you see in this bottle.

CAROLINE.

How it fumes when the stopper is taken out!

MRS. B.

The acid exists naturally in a gaseous state, and is here so strongly concentrated in water, that it is constantly escaping.

Here is another bottle of nitrous acid, which, you see, is of an orange red; this acid is weaker, the nitrogen being combined with a smaller quantity of oxygen; and with a still less proportion of oxygen it is an olive-green colour, as it appears in this third bottle. In short, the weaker the acid, the deeper is its colour.

Nitrous acid acts still more powerfully on some inflammable substances than the nitric.

EMILY.

I am surprised at that, as it contains less oxygen.

MRS. B.

But, on the other hand, it parts with its oxygen much more readily: you may recollect that we once inflamed oil with this acid.

The next combinations of nitrogen and oxygen form only oxyds of nitrogen, the first of which is commonly called *nitrous air*; or more properly *nitric oxyd gas*. This may be obtained from nitric acid, by exposing the latter to the action of metals,

as in dissolving them it does not yield the whole of its oxygen, but retains a portion of this principle sufficient to convert it into this peculiar gas, a specimen of which I have prepared, and preserved within this inverted glass bell.

EMILY.

It is a perfectly invisible elastic fluid.

MRS. B.

Yes; and it may be kept any length of time in this manner over water, as it is not, like the nitric and nitrous acids, absorbable by it. It is rather heavier than atmospherical air, and is incapable of supporting either combustion or respiration. I am going to incline the glass gently on one side, so as to let some of the gas escape —

EMILY.

How very curious! — It produces orange fumes like the nitrous acid! that is the more extraordinary, as the gas within the glass is perfectly invisible.

MRS. B.

It would give me much pleasure if you could make out the reason of this curious change without requiring any further explanation.

CAROLINE.

It seems, by the colour and smell, as if it were

converted into nitrous acid gas; yet that cannot be, unless it combines with more oxygen; and how can it obtain oxygen the very instant it escapes from the glass?

EMILY.

From the atmosphere, no doubt. Is it not so, Mrs. B.?

MRS. B.

You have guessed it; as soon as it comes in contact with the atmosphere, it absorbs from it the additional quantity of oxygen necessary to convert it into nitrous acid gas. And, if I now remove the bottle entirely from the water, so as to bring at once the whole of the gas into contact with the atmosphere, this conversion will appear still more striking —

EMILY.

Look, Caroline, the whole capacity of the bottle is instantly tinged of an orange colour!

MRS. B.

Thus, you see, it is the most easy process imaginable to convert *nitrous oxyd gas* into *nitrous acid gas*. The property of attracting oxygen from the atmosphere, without any elevation of temperature, has occasioned this gaseous oxyd being used as a test for ascertaining the degree of purity of

the atmosphere. I am going to show you how it is applied to this purpose. — You see this graduated glass tube, which is closed at one end, (Plate X. fig. 2.) — I first fill it with water, and then introduce a certain measure of nitrous gas, which, not being absorbable by water, passes through it, and occupies the upper part of the tube. I must now add rather above two-thirds of oxygen gas, which will just be sufficient to convert the nitrous oxyd gas into nitrous acid gas.

CAROLINE.

So it has! — I saw it turn of an orange colour; but it immediately afterwards disappeared entirely, and the water, you see, has risen, and almost filled the tube.

MRS. B.

That is because the acid gas is absorbable by water, and in proportion as the gas impregnates the water, the latter rises in the tube. When the oxygen gas is very pure, and the required proportion of nitrous oxyd gas very exact, the whole is absorbed by the water; but if any other gas be mixed with the oxygen, instead of combining with the nitrous oxygen, it will remain and occupy the upper part of the tube; or if the gases be not in the due proportion, there will be a residue of that which predominates. — Before we leave this subject,

I must not forget to remark that nitrous acid may be formed by dissolving nitrous oxyd gas in nitric acid. This solution may be effected simply by making bubbles of nitrous oxyd gas pass through nitric acid.

EMILY.

That is to say, that nitrogen at its highest degree of oxygenation, being mixed with nitrogen at its lowest degree of oxygenation, will produce a kind of intermediate substance, which is nitrous acid.

MRS. B.

You have stated the fact with great precision. — There are various other methods of preparing nitrous oxyd, and of obtaining it from compound bodies; but it is not necessary to enter into these particulars. It remains for me only to mention another curious modification of oxygenated nitrogen, which has been distinguished by the name of *gaseous oxyd of nitrogen*. It is but lately that this gas has been accurately examined, and its properties have been investigated chiefly by Sir H. Davy. It has obtained also the name of *exhilarating* gas, from the very singular property which that gentleman has discovered in it, of elevating the animal spirits, when inhaled into the lungs, to a degree sometimes resembling delirium or intoxication.

CAROLINE.

Is it respirable, then?

MRS. B.

It can scarcely be called respirable, as it would not support life for any length of time; but it may be breathed for a few moments without any other effects, than the singular exhilaration of spirits I have just mentioned. It affects different people, however, in a very different manner. Some become violent, even outrageous; others experience a langour, attended with faintness; but most agree in opinion, that the sensations it excites are extremely pleasant.

CAROLINE.

I think I should like to try it — how do you breathe it?

MRS. B.

By collecting the gas in a bladder, to which a short tube with a stop-cock is adapted; this is applied to the mouth with one hand, whilst the nostrils are kept closed with the other, that the common air may have no access. You then alternately inspire, and expire the gas, till you perceive its effects. But I cannot consent to your making the experiment; for the nerves are sometimes unpleasantly affected by it, and I would not run any risk of that kind.

EMILY.

I should like, at least, to see somebody breathe it; but pray by what means is this curious gas obtained?

MRS. B.

It is procured from *nitrat of ammonia*, an artificial salt which yields this gas on the application of a gentle heat. I have put some of the salt into a retort, and by the aid of a lamp the gas will be extricated.—

CAROLINE.

Bubbles of air begin to escape through the neck of the retort into the water apparatus; will you not collect them?

MRS. B.

The gas that first comes over need not be preserved, as it consists of little more than the common air that was in the retort; besides, there is always in this experiment a quantity of watery vapour which must come away before the nitrous oxyd appears.

EMILY.

Watery vapour! Whence does that proceed? There is no water in nitrat of ammonia?

MRS. B.

You must recollect that there is in every salt a quantity of water of crystallisation, which may

be evaporated by heat alone. But, besides this, water is actually generated in this experiment, as you will see presently. First tell me, what are the constituent parts of nitric of ammonia?

EMILY.

Ammonia, and nitric acid: this salt, therefore, contains three different elements, nitrogen and hydrogen, which produce the ammonia; and oxygen, which, with nitrogen, forms the acid.

MRS. B.

Well then, in this process the ammonia is decomposed; the hydrogen quits the nitrogen to combine with some of the oxygen of the nitric acid, and forms with it the watery vapour which is now coming over. When that is effected, what will you expect to find?

EMILY.

Nitrous acid instead of nitric acid, and nitrogen instead of ammonia.

MRS. B.

Exactly so; and the nitrous acid and nitrogen combine, and form the gaseous oxyd of nitrogen, in which the proportion of oxygen is 37 parts to 63 of nitrogen.

You may have observed, that for a little while

no bubbles of air have come over, and we have perceived only a stream of vapour condensing as it issued into the water. — Now bubbles of air again make their appearance, and I imagine that by this time all the watery vapour is come away, and that we may begin to collect the gas. We may try whether it is pure, by filling a phial with it, and plunging a taper into it — yes, it will do now, for the taper burns brighter than in the common air, and with a greenish flame.

CAROLINE.

But how is that? I thought no gas would support combustion but oxygen or chlorine.

MRS. B.

Or any gas that contains oxygen, and is ready to yield it, which is the case with this in a considerable degree; it is not, therefore, surprising that it should accelerate the combustion of the taper.

You see that the gas is now produced in great abundance; we shall collect a large quantity of it, and I dare say that we shall find some of the family who will be curious to make the experiment of respiring it. Whilst this process is going on, we may take a general survey of the most important combinations of the nitric and nitrous acids with the alkalies.

The first of these is *nitrat of potash*, commonly called *nitre* or *saltpetre*.

CAROLINE.

Is not that the salt with which gunpowder is made?

MRS. B.

Yes. Gunpowder is a mixture of five parts of nitre to one of sulphur, and one of charcoal.— Nitre, from its great proportion of oxygen, and from the facility with which it yields it, is the basis of most detonating compositions.

EMILY.

But what is the cause of the violent detonation of gunpowder when set fire to?

MRS. B.

Detonation may proceed from two causes; the sudden formation or destruction of an elastic fluid. In the first case, when either a solid or liquid is instantaneously converted into an elastic fluid, the prodigious and sudden expansion of the body strikes the air with great violence, and this concussion produces the sound called detonation.

CAROLINE.

That I comprehend very well; but how can a similar effect be produced by the destruction of a gas?

MRS. B.

A gas can be destroyed only by condensing it to a liquid or solid state; when this takes place suddenly, the gas, in assuming a new and more compact form, produces a vacuum, into which the surrounding air rushes with great impetuosity; and it is by that rapid and violent motion that the sound is produced. In all detonations, therefore, gases are either suddenly formed, or destroyed. In that of gunpowder, can you tell me which of these two circumstances takes place?

EMILY.

As gunpowder is a solid, it must, of course, produce the gases in its detonation; but how, I cannot tell.

MRS. B.

The constituents of gunpowder, when heated to a certain degree, enter into a number of new combinations, and are instantaneously converted into a variety of gases, the sudden expansion of which gives rise to the detonation.

CAROLINE.

And in what instance does the destruction or condensation of gases produce detonation?

MRS. B.

I can give you one with which you are well

acquainted; the sudden combination of the oxygen and hydrogen gases.

CAROLINE.

True; I recollect perfectly that hydrogen detonates with oxygen when the two gases are converted into water.

MRS. B.

But let us return to the nitrat of potash. — This salt is decomposed when exposed to heat, and mixed with any combustible body, such as carbon, sulphur, or metals, these substances oxydating rapidly at the expense of the nitrat. I must show you an instance of this. — I expose to the fire some of the salt in a small iron ladle, and, when it is sufficiently heated, add to it some powdered charcoal; this will attract the oxygen from the salt, and be converted into carbonic acid. —

EMILY.

But what occasions that crackling noise, and those vivid flashes that accompany it?

MRS. B.

The rapidity with which the carbonic acid gas is formed occasions a succession of small detonations, which, together with the emission of flame, is called *deflagration.*

Nitrat of ammonia we have already noticed,

on account of the gaseous oxyd of nitrogen which is obtained from it.

Nitrat of silver is the lunar caustic, so remarkable for its property of destroying animal fibre, for which purpose it is often used by surgeons.— We have said so much on a former occasion, on the mode in which caustics act on animal matter, that I shall not detain you any longer on this subject.

We now come to the CARBONIC ACID, which we have already had many opportunities of noticing. You recollect that this acid may be formed by the combustion of carbon, whether in its imperfect state of charcoal, or in its purest form of diamond. And it is not necessary, for this purpose, to burn the carbon in oxygen gas, as we did in the preceding lecture; for you need only light a piece of charcoal and suspend it under a receiver on the water bath. The charcoal will soon be extinguished, and the air in the receiver will be found mixed with carbonic acid. The process, however, is much more expeditious if the combustion be performed in pure oxygen gas.

CAROLINE.

But how can you separate the carbonic acid,

obtained in this manner, from the air with which it is mixed?

MRS. B.

The readiest mode is to introduce under the receiver a quantity of caustic lime, or caustic alkali, which soon attracts the whole of the carbonic acid to form a carbonat. — The alkali is found increased in weight, and the volume of the air is diminished by a quantity equal to that of the carbonic acid which was mixed with it.

EMILY.

Pray is there no method of obtaining pure carbon from carbonic acid?

MRS. B.

For a long time it was supposed that carbonic acid was not decompoundable; but Mr. Tennant discovered, a few years ago, that this acid may be decomposed by burning phosphorus in a closed vessel with carbonat of soda or carbonat of lime: the phosphorus absorbs the oxygen from the carbonat, whilst the carbon is separated in the form of a black powder. This decomposition, however, is not effected simply by the attraction of the phosphorus for oxygen, since it is weaker than that of charcoal; but the attraction of the alkali or lime for the phosphoric acid, unites its power at the same time.

CAROLINE.

Cannot we make that experiment?

MRS. B.

Not easily; it requires being performed with extreme nicety, in order to obtain any sensible quantity of carbon, and the experiment is much too delicate for me to attempt it. But there can be no doubt of the accuracy of Mr. Tennant's results; and all chemists now agree, that one hundred parts of carbonic acid gas consists of about twenty-eight parts of carbon to seventy-two of oxygen gas. But if you recollect, we decomposed carbonic acid gas the other day by burning potassium in it.

CAROLINE.

True, so we did; and found the carbon precipitated on the regenerated potash.

MRS. B.

Carbonic acid gas is found very abundantly in nature; it is supposed to form about one thousandth part of the atmosphere, and is constantly produced by the respiration of animals; it exists in a great variety of combinations, and is exhaled from many natural decompositions. It is contained in a state of great purity in certain caves, such as the *Grotto del Cane*, near Naples.

EMILY.

I recollect having read an account of that grotto, and of the cruel experiments made on the poor dogs, to gratify the curiosity of strangers. But I understood that the vapour exhaled by this cave was called *fixed air*.

MRS. B.

That is the name by which carbonic acid was known before its chemical composition was discovered. — This gas is more destructive of life than any other; and if the poor animals that are submitted to its effects are not plunged into cold water as soon as they become senseless, they do not recover. It extinguishes flame instantaneously. I have collected some in this glass, which I will pour over the candle.

CAROLINE.

This is extremely singular — it seems to extinguish the light as it were by enchantment, as the gas is invisible. I never should have imagined that gas could have been poured like a liquid.

MRS. B.

It can be done with carbonic acid only, as no other gas is sufficiently heavy to be susceptible of being poured out in the atmospherical air without mixing with it.

EMILY.

Pray by what means did you obtain this gas?

MRS. B.

I procured it from marble. Carbonic acid gas has so strong an attraction for all the alkalies and alkaline earths, that these are always found in nature in the state of carbonats. Combined with lime, this acid forms chalk, which may be considered as the basis of all kinds of marbles, and calcareous stones. From these substances carbonic acid is easily separated, as it adheres so slightly to its combinations, that the carbonats are all decomposable by any of the other acids. I can easily show you how I obtained this gas; I poured some diluted sulphuric acid over pulverised marble in this bottle (the same which we used the other day to prepare hydrogen gas), and the gas escaped through the tube connected with it; the operation still continues, as you may perceive—

EMILY.

Yes, it does; there is a great fermentation in the glass vessel. What singular commotion is excited by the sulphuric acid taking possession of the lime, and driving out the carbonic acid!

CAROLINE.

But did the carbonic acid exist in a gaseous state in the marble?

MRS. B.

Certainly not; the acid, when in a state of combination, is capable of existing in a solid form.

CAROLINE.

Whence, then, does it obtain the caloric necessary to convert it into gas?

MRS. B.

It may be supplied in this case from the mixture of sulphuric acid and water, which produces an evolution of heat, even greater than is required for the purpose; since, as you may perceive by touching the glass vessel, a considerable quantity of the caloric disengaged becomes sensible. But a supply of caloric may be obtained also from a diminution of capacity for heat, occasioned by the new combination which takes place; and, indeed, this must be the case when other acids are employed for the disengagement of carbonic acid gas, which do not, like the sulphuric, produce heat on being mixed with water. Carbonic acid may likewise be disengaged from its combinations by heat alone, which restores it to its gaseous state.

CAROLINE.

It appears to me very extraordinary that the same gas, which is produced by the burning of wood and coals should exist also in such bodies

as marble, and chalk, which are incombustible substances.

MRS. B.

I will not answer that objection, Caroline, because I think I can put you in a way of doing it yourself. Is carbonic acid combustible?

CAROLINE.

Why, no — because it is a body which has been already burnt; it is carbon only, and not the acid, that is combustible.

MRS. B.

Well, and what inference do you draw from this?

CAROLINE.

That carbonic acid cannot render the bodies with which it is united combustible; but that simple carbon does, and that it is in this elementary state that it exists in wood, coals, and a great variety of other combustible bodies. — Indeed, Mrs. B., you are very ungenerous; you are not satisfied with convincing me that my objections are frivolous, but you oblige me to prove them so myself.

MRS. B.

You must confess, however, that I make ample amends for the detection of error, when I enable

you to discover the truth. You, understand, now, I hope, that carbonic acid is equally produced by the decomposition of chalk, or by the combustion of charcoal. These processes are certainly of a very different nature; in the first case the acid is already formed, and requires nothing more than heat to restore it to its gaseous state; whilst, in the latter, the acid is actually made by the process of combustion.

CAROLINE.

I understand it now perfectly. But I have just been thinking of another difficulty, which, I hope, you will excuse my not being able to remove myself. How does the immense quantity of calcareous earth, which is spread all over the globe, obtain the carbonic acid with which it is combined?

MRS. B.

The question is, indeed, not very easy to answer; but I conceive that the general carbonisation of calcareous matter may have been the effect of a general combustion, occasioned by some revolution of our globe, and producing an immense supply of carbonic acid, with which the calcareous matter became impregnated; or that this may have been effected by a gradual absorption of carbonic acid from the atmosphere. — But this would lead us to discussions which we cannot in-

dulge in, without deviating too much from our subject.

EMILY.

How does it happen that we do not perceive the pernicious effects of the carbonic acid which is floating in the atmosphere?

MRS. B.

Because of the state of very great dilution in which it exists there. But can you tell me, Emily, what are the sources which keep the atmosphere constantly supplied with this acid?

EMILY.

I suppose the combustion of wood, coals, and other substances, that contain carbon.

MRS. B.

And also the breath of animals.

CAROLINE.

The breath of animals! I thought you said that this gas was not at all respirable, but on the contrary, extremely poisonous.

MRS. B.

So it is; but although animals cannot breathe in carbonic acid gas, yet, in the process of respiration, they have the power of forming this gas in

their lungs; so that the air which we *expire*, or reject from the lungs, always contains a certain proportion of carbonic acid, which is much greater than that which is commonly found in the atmosphere.

CAROLINE.

But what is it that renders carbonic acid such a deadly poison?

MRS. B.

The manner in which this gas destroys life, seems to be merely by preventing the access of respirable air; for carbonic acid gas, unless very much diluted with common air, does not penetrate into the lungs, as the windpipe actually contracts and refuses it admittance. — But we must dismiss this subject at present, as we shall have an opportunity of treating of respiration much more fully, when we come to the chemical functions of animals.

EMILY.

Is carbonic acid as destructive to the life of vegetables as it is to that of animals.

MRS. B.

If a vegetable be completely immersed in it, I believe it generally proves fatal to it; but mixed in certain proportions with atmospherical air, it is, on the contrary, very favourable to vegetation.

You remember, I suppose, our mentioning the mineral waters, both natural and artificial, which contain carbonic acid gas?

CAROLINE.

You mean the Seltzer water?

MRS. B.

That is one of those which are the most used; there are, however, a variety of others into which carbonic acid enters as an ingredient: all these waters are usually distinguished by the name of *acidulous* or *gaseous mineral waters.*

The class of salts called *carbonats* is the most numerous in nature; we must pass over them in a very cursory manner, as the subject is far too extensive for us to enter on it in detail. The state of carbonat is the natural state of a vast number of minerals, and particularly of the alkalies and alkaline earths, as they have so great an attraction for the carbonic acid, that they are almost always found combined with it; and you may recollect that it is only by separating them from this acid, that they acquire that causticity and those striking qualities which I have formerly described. All marbles, chalks, shells, calcareous spars, and limestones of every description, are neutral salts, in which *lime*, their common basis, has lost all its characteristic properties.

EMILY.

But if all these various substances are formed by the union of lime with carbonic acid, whence arises their diversity of form and appearance?

MRS. B.

Both from the different proportions of their component parts, and from a variety of foreign ingredients which may be occasionally blended with them: the veins and colours of marbles, for instance, proceed from a mixture of metallic substances; silex and alumine also frequently enter into these combinations. The various carbonats, therefore, which I have enumerated, cannot be considered as pure unadulterated neutral salts, although they certainly belong to that class of bodies.

CONVERSATION XIX.

ON THE BORACIC, FLUORIC, MURIATIC, AND OXYGENATED MURIATIC ACIDS; AND ON MURIATS. — ON IODINE AND IODIC ACID.

MRS. B.

We now come to the three remaining acids with simple bases, the compound nature of which, though long suspected, has been but recently proved. The chief of these is the muriatic; but I shall first describe the two others, as their bases have been obtained more distinctly than that of the muriatic acid.

You may recollect I mentioned the BORACIC ACID. This is found very sparingly in some parts of Europe, but for the use of manufactures we have always received it from the remote country of Thibet, where it is found in some lakes, combined with soda. It is easily separated from the soda by sulphuric acid, and appears in the form of shining scales, as you see here.

CAROLINE.

I am glad to meet with an acid which we need

not be afraid to touch; for I perceive, from your keeping it in a piece of paper, that it is more innocent than our late acquaintance, the sulphuric and nitric acids.

MRS. B.

Certainly; but being more inert, you will not find its properties so interesting. However its decomposition, and the brilliant spectacle it affords when its basis again unites with oxygen, atones for its want of other striking qualities.

Sir H. Davy succeeded in decomposing the boracic acid, (which had till then, been considered as undecompoundable,) by various methods. On exposing this acid to the Voltaic battery, the positive wire gave out oxygen, and on the negative wire was deposited a black substance, in appearance resembling charcoal. This was the basis of the acid, which Sir H. Davy has called *Boracium*, or *Boron*.

The same substance was obtained in more considerable quantities, by exposing the acid to a great heat in an iron gun-barrel.

A third method of decomposing the boracic acid consisted in burning potassium in contact with it in vacuo. The potassium attracts the oxygen from the acid, and leaves its basis in a separate state.

The recomposition of this acid I shall show

you, by burning some of its basis, which you see here, in a retort full of oxygen gas. The heat of a candle is all that is required for this combustion. —

EMILY.

The light is astonishingly brilliant, and what beautiful sparks it throws out!

MRS. B.

The result of this combustion is the boracic acid, the nature of which, you see, is proved both by analytic and synthetic means. Its basis has not, it is true, a metallic appearance; but it makes very hard alloys with other metals.

EMILY.

But pray, Mrs. B., for what purpose is the boracic acid used in manufactures?

MRS. B.

Its principal use is in conjunction with soda, that is, in the state of *borat of soda*, which in the arts is commonly called borax. This salt has a peculiar power of dissolving metallic oxyds, and of promoting the fusion of substances capable of being melted; it is accordingly employed in various metallic arts; it is used, for example, to remove the oxyd from the surface of metals, and

is often employed in the assaying of metallic ores.

Let us now proceed to the FLUORIC ACID. This acid is obtained from a substance which is found frequently in mines, and particularly in those of Derbyshire, called *fluor*, a name which it acquired from the circumstance of its being used to render the ores of metals more fluid when heated.

CAROLINE.

Pray is not this the Derbyshire spar, of which so many ornaments are made?

MRS. B.

The same; but though it has long been employed for a variety of purposes, its nature was unknown until Scheele, the great Swedish chemist, discovered that it consisted of lime united with a peculiar acid, which obtained the name of *fluoric acid*. It is easily separated from the lime by the sulphuric acid, and unless condensed in water, ascends in the form of gas. A very peculiar property of this acid is its union with siliceous earths, which I have already mentioned. If the distillation of this acid is performed in glass vessels, they are corroded, and the siliceous part of the glass comes over, united with the gas; if water

is then admitted, part of the silex is deposited, as you may observe in this jar.

CAROLINE.

I see white flakes forming on the surface of the water; is that silex?

MRS. B.

Yes it is. This power of corroding glass has been used for engraving, or rather etching, upon it. The glass is first covered with a coat of wax, through which the figures to be engraved are to be scratched with a pin; then pouring the fluoric acid over the wax, it corrodes the glass where the scratches have been made.

CAROLINE.

I should like to have a bottle of this acid, to make engravings.

MRS. B.

But you could not have it in a *glass* bottle, for in that case the acid would be saturated with silex, and incapable of executing an engraving; the same thing would happen were the acid kept in vessels of porcelain or earthen-ware; this acid must therefore be both prepared and preserved in vessels of silver.

If it be distilled from fluor spar and vitriolic acid, in silver or leaden vessels, the receiver being kept very cold during the distillation, it assumes the form of a dense fluid, and in that state is the most intensely corrosive substance known. This seems to be the acid combined with a little water. It may be called *hydro-fluoric acid;* and Sir H. Davy has been led, from some late experiments on the subject, to consider *pure* fluoric acid as a compound of a certain unknown principle, which he calls *fluorine*, with hydrogen.

Sir H. Davy has also attempted to decompose the fluoric acid by burning potassium in contact with it; but he has not yet been able by this or any other method, to obtain its basis in a distinct separate state.

We shall conclude our account of the acids with that of the MURIATIC ACID, which is perhaps the most curious and interesting of all of them. It is found in nature combined with soda, lime, and magnesia. *Muriat of soda* is the common sea-salt, and from this substance the acid is usually disengaged by means of the sulphuric acid. The natural state of the muriatic acid is that of an invisible permanent gas, at the common temperature of the atmosphere; but it has a remarkably strong attraction for water, and as-

sumes the form of a whitish cloud whenever it meets any moisture to combine with. This acid is remarkable for its peculiar and very pungent smell, and possesses, in a powerful degree, most of the acid properties. Here is a bottle containing muriatic acid in a liquid state.

CAROLINE.

And how is it liquefied?

MRS. B.

By impregnating water with it; its strong attraction for water makes it very easy to obtain it in a liquid form. Now, if I open the phial, you may observe a kind of vapour rising from it, which is muriatic acid gas, of itself invisible, but made apparent by combining with the moisture of the atmosphere.

EMILY.

Have you not any of the pure muriatic acid gas?

MRS. B.

This jar is full of that acid in its gaseous state — it is inverted over mercury instead of water, because, being absorbable by water, this gas cannot be confined by it. — I shall now raise the jar a little on one side, and suffer some of the gas to

escape. — You see that it immediately becomes visible in the form of a cloud.

EMILY.

It must be, no doubt, from its uniting with the moisture of the atmosphere, that it is converted into this dewy vapour.

MRS. B.

Certainly; and for the same reason, that is to say, its extreme eagerness to unite with water, this gas will cause snow to melt as rapidly as an intense fire.

This acid proved much more refractory when Sir H. Davy attempted to decompose it than the other two undecompounded acids. It is singular that potassium will burn in muriatic acid, and be converted into potash, without decomposing the acid, and the result of this combustion is a *muriat of potash*; for the potash, as soon as it is regenerated, combines with the muriatic acid.

CAROLINE.

But how can the potash be regenerated if the muriatic acid does not oxydate the potassium?

MRS. B.

The potassium, in this process, obtains oxygen from the moisture with which the muriatic acid is

always combined, and accordingly hydrogen, resulting from the decomposition of the moisture, is invariably evolved.

EMILY.

But why not make these experiments with dry muriatic acid?

MRS. B.

Dry acids cannot be acted on by the Voltaic battery, because acids are non-conductors of electricity, unless moistened. In the course of a number of experiments which Sir H. Davy made upon acids in a state of dryness, he observed that the presence of water appeared always necessary to develope the acid properties, so that acids are not even capable of reddening vegetable blues if they have been carefully deprived of moisture. This remarkable circumstance led him to suspect, that water, instead of oxygen, may be the acidifying principle; but this he threw out rather as a conjecture than as an established point.

Sir H. Davy obtained very curious results from burning potassium in a mixture of phosphorus and muriatic acid, and also of sulphur and muriatic acid; the latter detonates with great violence. All his experiments, however, failed in presenting to his view the basis of the muriatic acid, of which he was in search; and he was at last induced to

form an opinion respecting the nature of this acid, which I shall presently explain.

EMILY.

Is this acid susceptible of different degrees of oxygenation?

MRS. B.

Yes, for though we cannot deoxygenate this acid, yet we may add oxygen to it.

CAROLINE.

Why then, is not the least degree of oxygenation of the acid called the *muriatous*, and the higher degree the *muriatic* acid?

MRS. B.

Because, instead of becoming, like other acids, more dense, and more acid by an addition of oxygen, it is rendered on the contrary more volatile, more pungent, but less acid, and less absorbable by water. These circumstances, therefore, seem to indicate the propriety of making an exception to the nomenclature. The highest degree of oxygenation of this acid has been distinguished by the additional epithet of *oxygenated*, or, for the sake of brevity, *oxy*, so that it is called the *oxygenated*, or *oxy-muriatic acid*. This likewise exists in a gaseous form, at the temperature of the atmosphere; it is also susceptible of being absorbed

by water, and can be congealed, or solidified, by a certain degree of cold.

EMILY.

And how do you obtain the oxy-muriatic acid?

MRS. B.

In various ways; but it may be most conveniently obtained by distilling liquid muriatic acid over oxyd of manganese, which supplies the acid with the additional oxygen. One part of the acid being put into a retort, with two parts of the oxyd of manganese, and the heat of a lamp applied, the gas is soon disengaged, and may be received over water, as it is but sparingly absorbed by it. — I have collected some in this jar —

CAROLINE.

It is not invisible, like the generality of gases; for it is of a yellowish colour.

MRS. B.

The muriatic acid extinguishes flame, whilst, on the contrary, the oxy-muriatic makes the flame larger, and gives it a dark red colour. Can you account for this difference in the two acids?

EMILY.

Yes, I think so; the muriatic acid will not sup-

ply the flame with the oxygen necessary for its support; but when this acid is further oxygenated, it will part with its additional quantity of oxygen, and in this way support combustion.

MRS. B.

That is exactly the case; indeed the oxygen added to the muriatic acid, adheres so slightly to it, that it is separated by mere exposure to the sun's rays. This acid is decomposed also by combustible bodies, many of which it burns, and actually inflames, without any previous increase of temperature.

CAROLINE.

That is extraordinary, indeed! I hope you mean to indulge us with some of these experiments?

MRS. B.

I have prepared several glass jars of oxy-muriatic acid gas for that purpose. In the first we shall introduce some Dutch gold leaf.— Do you observe that it takes fire?

EMILY.

Yes, indeed it does — how wonderful it is! It became immediately red hot, but was soon smothered in a thick vapour.

CAROLINE.

What a disagreeable smell!

MRS. B.

We shall try the same experiment with phosphorus in another jar of this acid.—You had better keep your handkerchief to your nose when I open it—now let us drop into it this little piece of phosphorus—

CAROLINE.

It burns really; and almost as brilliantly as in oxygen gas! But, what is most extraordinary, these combustions take place without the metal or phosphorus being previously lighted, or even in the least heated.

MRS. B.

All these curious effects are owing to the very great facility with which this acid yields oxygen to such bodies as are strongly disposed to combine with it. It appears extraordinary indeed to see bodies, and metals in particular, melted down and inflamed, by a gas without any increase of temperature, either of the gas, or of the combustible. The phenomenon, however, is, you see, well accounted for.

EMILY.

Why did you burn a piece of Dutch gold leaf rather than a piece of any other metal?

MRS. B.

Because, in the first place, it is a composition

of metals (consisting chiefly of copper) which burns readily; and I use a thin metallic leaf in preference to a lump of metal, because it offers to the action of the gas but a small quantity of matter under a large surface. Filings, or shavings, would answer the purpose nearly as well; but a lump of metal, though the surface would oxydate with great rapidity, would not take fire. Pure gold is not inflamed by oxy-muriatic acid gas, but it is rapidly oxydated, and dissolved by it; indeed, this acid is the only one that will dissolve gold.

EMILY.

This, I suppose, is what is commonly called *aqua regia*, which you know is the only thing that will act upon gold.

MRS. B.

That is not exactly the case either; for aqua regia is composed of a mixture of muriatic acid and nitric acid. — But, in fact, the result of this mixture is the formation of oxy-muriatic acid, as the muriatic acid oxygenates itself at the expence of the nitric; this mixture, therefore, though it bears the name of *nitro-muriatic acid*, acts on gold merely in virtue of the oxy-muriatic acid which it contains.

Sulphur, volatile oils, and many other substances, will burn in the same manner in oxy-muriatic

acid gas; but I have not prepared a sufficient quantity of it, to show you the combustion of all these bodies.

CAROLINE.

There are several jars of the gas yet remaining.

MRS. B.

We must reserve these for future experiments. The oxy-muriatic acid does not, like other acids, redden the blue vegetable colours; but it totally destroys all colour, and turns vegetables perfectly white. Let us collect some vegetable substances to put into this glass, which is full of gas.

EMILY.

Here is a sprig of myrtle —

CAROLINE.

And here some coloured paper —

MRS. B.

We shall also put in this piece of scarlet riband, and a rose —

EMILY.

Their colours begin to fade immediately? But how does the gas produce this effect?

MRS. B.

The oxygen combines with the colouring matter of these substances, and destroys it; that is to say,

destroys the property which these colours had of reflecting only one kind of rays, and renders them capable of reflecting them all, which, you know, will make them appear white. Old prints may be cleaned by this acid, for the paper will be whitened without injury to the impression, as printer's ink is made of materials (oil and lamp black) which are not acted upon by acids.

This property of the oxy-muriatic acid has lately been employed in manufactures in a variety of bleaching processes; but for these purposes the gas must be dissolved in water, as the acid is thus rendered much milder and less powerful in its effects; for, in a gaseous state, it would destroy the texture, as well as the colour of the substance submitted to its action.

CAROLINE.

Look at the things which we put into the gas; they have now entirely lost their colour!

MRS. B.

The effect of the acid is almost completed; and if we were to examine the quantity that remains, we should find it to consist chiefly of muriatic acid.

The oxy-muriatic acid has been used to purify the air in fever hospitals and prisons, as it burns and destroys putrid effluvia of every kind. The

infection of the small-pox is likewise destroyed by this gas, and matter that has been submitted to its influence will no longer generate that disorder.

CAROLINE.

Indeed, I think the remedy must be nearly as bad as the disease; the oxy-muriatic acid has such a dreadfully suffocating smell.

MRS. B.

It is certainly extremely offensive: but by keepin the mouth shut, and wetting the nostrils with liquid ammonia, in order to neutralize the vapour as it reaches the nose, its prejudicial effects may be in some degree prevented. At any rate, however, this mode of disinfection can hardly be used in places that are inhabited. And as the vapour of nitric acid, which is scarcely less efficacious for this purpose, is not at all prejudicial, it is usually preferred on such occasions.

CAROLINE.

You have not told us yet what is Sir H. Davy's new opinion respecting the nature of muratic acid, to which you alluded a few minutes ago?

MRS. B.

True; I avoided noticing it then, because you could not have understood it without some pre-

vious knowledge of the oxy-muriatic acid, which I have but just introduced to your acquaintance.

Sir H. Davy's idea is that muriatic acid, instead of being a compound, consisting of an unknown basis and oxygen, is formed by the union of oxy-muriatic gas with hydrogen.

EMILY.

Have you not told us just now that oxy-muriatic gas was itself a compound of muriatic acid and oxygen?

MRS. B.

Yes; but according to Sir H. Davy's hypothesis, oxy-muriatic gas is considered as a simple body, which contains no oxygen — as a substance of its own kind, which has a great analogy to oxygen in most of its properties, though in others it differs entirely from it. — According to this view of the subject, the name of *oxy-muriatic acid* can no longer be proper, and therefore Sir H. Davy has adopted that of *chlorine*, or *chlorine gas*, a name which is simply expressive of its greenish colour; and in compliance with that philosopher's theory, we have placed chlorine in our table among the simple bodies.

CAROLINE.

But what was Sir H. Davy's reason for adopting an opinion so contrary to that which had hitherto prevailed?

MRS. B.

There are many circumstances which are favourable to the new doctrine; but the clearest and simplest fact in its support is, that if hydrogen gas and oxy-muriatic gas be mixed together, both these gases disappear, and muriatic acid gas is formed.

EMILY.

That seems to be a complete proof; is it not considered as perfectly conclusive?

MRS. B.

Not so decisive as it appears at first sight; because it is argued by those who still incline to the old doctrine, that muriatic acid gas, however dry it may be, always contains a certain quantity of water, which is supposed essential to its formation. So that, in the experiment just mentioned, this water is supplied by the union of the hydrogen gas with the oxygen of the oxy-muriatic acid; and therefore the mixture resolves itself into the base of muriatic acid and water, that is, muriatic acid gas.

CAROLINE.

I think the old theory must be the true one; for otherwise how could you explain the formation of oxy-muriatic gas, from a mixture of muriatic acid and oxyd of manganese?

MRS. B.

Very easily; you need only suppose that in this process the muriatic acid is decomposed; its hydrogen unites with the oxygen of the manganese to form water, and the chlorine appears in its separate state.

EMILY.

But how can you explain the various combustions which take place in oxy-muriatic gas, if you consider it as containing no oxygen?

MRS. B.

We need only suppose that combustion is the result of intense chemical action; so that chlorine, like oxygen, in combining with bodies, forms compounds which have less capacity for caloric than their constituent principles, and, therefore, caloric is evolved at the moment of their combination.

EMILY.

If, then, we may explain every thing by either theory, to which of the two shall we give the preference?

MRS. B.

It will, perhaps, be better to wait for more positive proofs, if such can be obtained, before we decide positively upon the subject. The new doctrine has certainly gained ground very rapidly, and may be considered as nearly established; but seve-

ral competent judges still refuse their assent to it, and until that theory is very generally adopted, it may be as well for us still occasionally to use the language to which chemists have long been accustomed. — But let us proceed to the examination of salts formed by muriatic acid.

Among the compound salts formed by muriatic acid, the *muriat of soda*, or common salt, is the most interesting.* The uses and properties of this salt are too well known to require much comment. Besides the pleasant flavour it imparts to the food, it is very wholesome, when not used to excess, as is assists the process of digestion.

Sea-water is the great source from which muriat of soda is extracted by evaporation. But it is also found in large solid masses in the bowels of the earth, in England, and in many other parts of the world.

EMILY.

I thought that salts, when solid, were always in the state of crystals; but the common table-salt is in the form of a coarse white powder.

* According to Sir H. Davy's views of the nature of the muriatic and oxy-muriatic acids, dry muriat of soda is a compound of sodium and chlorine, for it may be formed by the direct combination of oxy-muriatic gas and sodium. In his opinion, therefore, what we commonly call muriat of soda contains neither soda nor muriatic acid.

MRS. B.

Cystallisation depends, as you may recollect, on the slow and regular reunion of particles dissolved in a fluid; common sea-salt is only in a state of imperfect crystallisation, because the process by which it is prepared is not favourable to the formation of regular crystals. But if you dissolve it, and afterwards evaporate the water slowly, you will obtain a regular crystallisation.

Muriat of ammonia is another combination of this acid, which we have already mentioned as the principal source from which ammonia is derived.

I can at once show you the formation of this salt by the immediate combination of muriatic acid with ammonia. — These two glass jars contain, the one muriatic acid gas, the other ammoniacal gas, both of which are perfectly invisible — now, if I mix them together, you see they immediately form an opaque white cloud, like smoke. — If a thermometer was placed in the jar in which these gases are mixed, you would perceive that some heat is at the same time produced.

EMILY.

The effects of chemical combinations are, indeed, wonderful! — How extraordinary it is that two invisible bodies should become visible by their union!

MRS. B.

This strikes you with astonishment, because it is a phenomena which nature seldom exhibits to our view; but the most common of her operations are as wonderful, and it is their frequency only that prevents our regarding them with equal admiration. What would be more surprising, for instance, than combustion, were it not rendered so familiar by custom?

EMILY.

That is true.—But pray, Mrs. B., is this white cloud the salt that produces ammonia? How different it is from the solid muriat of ammonia which you once showed us!

MRS. B.

It is the same substance which first appears in the state of vapour, but will soon be condensed by cooling against the sides of the jar, in the form of very minute crystals.

We may now proceed to the *oxy-muriats.* In this class of salts the *oxy-muriat of potash* is the most worthy of our attention, for its striking properties. The acid, in this state of combination, contains a still greater proportion of oxygen than when alone.

CAROLINE.

But how can the oxy-muriatic acid acquire an increase of oxygen by combining with potash?

MRS. B.

It does not really acquire an additional quantity of oxygen, but it loses some of the muriatic acid, which produces the same effect, as the acid which remains is proportionably super-oxygenated.*

If this salt be mixed, and merely rubbed together with sulphur, phosphorus, charcoal, or indeed any other combustible, it explodes strongly.

CAROLINE.

Like gun-powder, I suppose, it is suddenly converted into elastic fluids?

MRS. B.

Yes; but with this remarkable difference, that no increase of temperature, any further than is produced by gentle friction, is required in this instance. Can you tell me what gases are generated by the detonation of this salt with charcoal?

EMILY.

Let me consider . . . . . The oxy-muriatic acid parts with its excess of oxygen to the charcoal, by which means it is converted into muriatic acid gas; whilst the charcoal, being burnt by the oxygen, is

* According to Sir. H. Davy's new views, just explained, oxy-muriat of potash is a compound of chlorine with oxyd of potassium.

changed to carbonic acid gas — What becomes of the potash I cannot tell.

MRS. B.

That is a fixed product which remains in the vessel.

CAROLINE.

But since the potash does not enter into the new combinations, I do not understand of what use it is in this operation. Would not the oxy-muriatic acid and the charcoal produce the same effect without it?

MRS. B.

No; because there would not be that very great concentration of oxygen which the combination with the potash produces, as I have just explained.

I mean to show you this experiment, but I would advise you not to repeat it alone; for if care be not taken to mix only very small quantities at a time, the detonation will be extemely violent, and may be be attended with dangerous effects. You see I mix an exceedingly small quantity of the salt with a little powdered charcoal, in this Wedgwood mortar, and rub them together with the pestle—

CAROLINE.

Heavens! How can such a loud explosion be produced by so small a quantity of matter?

MRS. B.

You must consider that an extremely small quantity of solid substance may produce a very great volume of gases; and it is the sudden evolution of these which occasions the sound.

EMILY.

Would not oxy-muriat of potash make stronger gun-powder than nitrat of potash?

MRS. B.

Yes; but the preparation, as well as the use of this salt, is attended with so much danger, that it is never employed for that purpose.

CAROLINE.

There is no cause to regret it, I think; for the common gun-powder is quite sufficiently destructive.

MRS. B.

I can show you a very curious experiment with this salt; but it must again be on condition that you will never attempt to repeat it by yourselves. I throw a small piece of phosphorus into this glass of water; then a little oxy-muriat of potash; and, lastly, I pour in (by means of this funnel, so as to bring it in contact with the two other ingredients at the bottom of the glass) a small quantity of sulphuric acid —

CAROLINE.

This is, indeed, a beautiful experiment! The phosphorus takes fire and burns from the bottom of the water.

EMILY.

How wonderful it is to see flame bursting out under water, and rising through it! Pray, how is this accounted for?

MRS. B.

Cannot you find it out, Caroline?

EMILY.

Stop — I think I can explain it. Is it not because the sulphuric acid decomposes the salt by combining with the potash, so as to liberate the oxy-muriatic acid gas by which the phosphorus is set on fire?

MRS. B.

Very well, Emily; and with a little more reflection you would have discovered another concurring circumstance, which is, that an increase of temperature is produced by the mixture of the sulphuric acid and water, which assists in promoting the combustion of the phosphorus.

I must, before we part, introduce to your acquaintance the newly-discovered substance IODINE, which you may recollect we placed next to oxygen and chlorine in our table of simple bodies.

CAROLINE.

Is this also a body capable of maintaining combustion like oxygen and chlorine?

MRS. B.

It is; and although it does not so generally disengage light and heat from inflammable bodies, as oxygen and chlorine do, yet it is capable of combining with most of them; and sometimes, as in the instance of potassium and phosphorus, the combination is attended with an actual appearance of light and heat.

CAROLINE.

But what sort of a substance is iodine: what is its form, and colour?

MRS. B.

It is a very singular body, in many respects. At the ordinary temperature of the atmosphere, it commonly appears in the form of blueish black crystalline scales, such as you see in this tube.

CAROLINE.

They shine like black lead, and some of the scales have the shape of lozenges.

MRS. B.

That is actually the form which the crystals of iodine often assume. But if we heat them gently,

by holding the tube over the flame of a candle, see what a change takes place in them.

CAROLINE.

How curious! They seem to melt, and the tube immediately fills with a beautiful violet vapour. But look, Mrs. B., the same scales are now appearing at the other end of the tube.

MRS. B.

This is in fact a sublimation of iodine, from one part of the tube to another; but with this remarkable peculiarity, that, while in the gaseous state, iodine assumes that bright violet colour, which, as you may already perceive, it loses as the tube cools, and the substance resumes its usual solid form. — It is from the violet colour of the gas that iodine has obtained its name.

CAROLINE.

But how is this curious substance obtained?

MRS. B.

It is found in the ley of ashes of sea-weeds, after the soda has been separated by crystallisation; and it is disengaged by means of sulphuric acid, which expels it from the alkaline ley in the form of a violet gas, which may be collected and condensed in the way you have just

seen. — This interesting discovery was made in the year 1812, by M. Courtois, a manufacturer of saltpetre at Paris.

CAROLINE.

And pray, Mrs. B., what is the proof of iodine being a simple body?

MRS. B.

It is considered as a simple body, both because it is not capable of being resolved into other ingredients; and because it is itself capable of combining with other bodies, in a manner analogous to oxygen and chlorine. The most curious of these combinations is that which it forms with hydrogen gas, the result of which is a peculiar gaseous acid.

CAROLINE.

Just as chlorine and hydrogen gas form muriatic acid? In this respect chlorine and iodine seem to bear a strong analogy to each other.

MRS. B.

That is indeed the case; so that if the theory of the constitution of either of these two bodies be true, it must be true also in regard to the other; if erroneous in the one, the theory must fall in both.

But it is now time to conclude; we have examined such of the acids and salts as I conceived would appear to you most interesting. — I shall not enter into any particulars respecting the metallic acids, as they offer nothing sufficiently striking for our present purpose.

CONVERSATION XX.

ON THE NATURE AND COMPOSITION OF VEGETABLES.

MRS. B.

We have hitherto treated only of the simplest combinations of elements, such as alkalies, earths, acids, compound salts, stones, &c.; all of which belong to the mineral kingdom. It is time now to turn our attention to a more complicated class of compounds, that of ORGANISED BODIES, which will furnish us with a new source of instruction and amusement.

EMILY.

By organised bodies, I suppose, you mean the vegetable and animal creation? I have, however, but a very vague idea of the word *organisation*, and I have often wished to know more precisely what it means.

MRS. B.

Organised bodies are such as are endowed by nature with various parts, peculiarly constructed and adapted to perform certain functions connected with life. Thus you may observe, that mineral compounds are formed by the simple effect of mechanical or chemical attraction, and may appear to some to be in a great measure the productions of chance; whilst organised bodies bear the most striking and impressive marks of design, and are eminently distinguished by that unknown principle, called *life*, from which the various organs derive the power of exercising their respective functions.

CAROLINE.

But in what manner does life enable these organs to perform their several functions?

MRS. B.

That is a mystery which, I fear, is enveloped in such profound darkness that there is very little hope of our ever being able to unfold it. We must content ourselves with examining the effects of this principle; as for the cause, we have been able only to give it a name, without attaching any other meaning to it than the vague and unsatisfactory idea of an unknown agent.

CAROLINE.

And yet I think I can form a very clear idea of life.

MRS. B.

Pray let me hear how you would define it?

CAROLINE.

It is perhaps more easy to conceive than to express — let me consider — Is not life the power which enables both the animal and the vegetable creation to perform the various functions which nature has assigned to them?

MRS. B.

I have nothing to object to your definition; but you will allow me to observe, that you have only mentioned the effects which the unknown cause produces, without giving us any notion of the cause itself.

EMILY.

Yes, Caroline, you have told us what life *does*, but you have not told us what it *is*.

MRS. B.

We may study its operations, but we should puzzle ourselves to no purpose by attempting to form an idea of its real nature.

We shall begin with examining its effects in the

vegetable world, which constitutes the simplest class of organised bodies; these we shall find distinguished from the mineral creation, not only by their more complicated nature, but by the power which they possess within themselves, of forming new chemical arrangements of their constituent parts, by means of appropriate organs. Thus, though all vegetables are ultimately composed of hydrogen, carbon, and oxygen, (with a few other occasional ingredients,) they separate and combine these principles by their various organs, in a thousand ways, and form, with them, different kinds of juices and solid parts, which exist ready made in vegetables, and may, therefore, be considered as their immediate materials.

These are:

Sap,	*Resins,*
Mucilage,	*Gum Resins,*
Sugar,	*Balsams,*
Fecula,	*Caoutchouc,*
Gluten,	*Extractive colouring Matter,*
Fixed Oil,	*Tannin,*
Volatile Oil,	*Woody Fibre,*
Camphor,	*Vegetable Acids, &c.*

CAROLINE.

What a long list of names! I did not suppose

that a vegetable was composed of half so many ingredients.

MRS. B.

You must not imagine that every one of these materials is formed in each individual plant. I only mean to say, that they are all derived exclusively from the vegetable kingdom.

EMILY.

But does each particular part of the plant, such as the root, the bark, the stem, the seeds, the leaves, consist of one of these ingredients only, or of several of them combined together?

MRS. B.

I believe there is no part of a plant which can be said to consist solely of any one particular ingredient; a certain number of vegetable materials must always be combined for the formation of any particular part, (of a seed for instance,) and these combinations are carried on by sets of vessels, or minute organs, which select from other parts, and bring together, the several principles required for the developement and growth of those particular parts which they are intended to form and to maintain.

EMILY.

And are not these combinations always regulated by the laws of chemical attraction?

MRS. B.

No doubt; the organs of plants cannot force principles to combine that have no attraction for each other; nor can they compel superior attractions to yield to those of inferior power; they probably act rather mechanically, by bringing into contact such principles, and in such proportions, as will, by their chemical combination, form the various vegetable products.

CAROLINE.

We may then consider each of these organs as a curiously constructed apparatus, adapted for the performance of a variety of chemical processes.

MRS. B.

Exactly so. As long as the plant lives and thrives, the carbon, hydrogen, and oxygen, (the chief constituents of its immediate materials,) are so balanced and connected together, that they are not susceptible of entering into other combinations; but no sooner does death take place, than this state of equilibrium is destroyed, and new combinations produced.

EMILY.

But why should death destroy it; for these principles must remain in the same proportions, and consequently, I should suppose, in the same order of attractions?

MRS. B.

You must remember, that in the vegetable, as well as in the animal kigdom, it is by the principle of *life* that the organs are enabled to act; when deprived of that agent or stimulus, their power ceases, and an order of attractions succeeds similar to that which would take place in mineral or unorganized matter.

EMILY.

It is this new order of attractions, I suppose, that destroys the organisation of the plant after death; for if the same combinations still continued to prevail, the plant would always remain in the state in which it died?

MRS. B.

And that, you know, is never the case; plants may be partially preserved for some time after death, by drying; but in the natural course of events they all return to the state of simple elements; a wise and admirable dispensation of Providence, by which dead plants are rendered fit to enrich the soil, and become subservient to the nourishment of living vegetables.

CAROLINE.

But we are talking of the dissolution of plants, before we have examined them in their living state.

MRS. B.

That is true, my dear. But I wished to give you a general idea of the nature of vegetation, before we entered into particulars. Besides, it is not so irrelevant as you suppose to talk of vegetables in their dead state, since we cannot analyze them without destroying life; and it is only by hastening to submit them to examination, immediately after they have ceased to live, that we can anticipate their natural decomposition. There are two kinds of analysis of which vegetables are susceptible; first, that which separates them into their immediate materials, such as sap, resin, mucilage, &c.; secondly, that which decomposes them into their primitive elements, as carbon, hydrogen, and oxygen.

EMILY.

Is there not a third kind of analysis of plants, which consists in separating their various parts, as the stem, the leaves, and the several organs of the flower?

MRS. B.

That, my dear, is rather the department of the botanist; we shall consider these different parts of plants only, as the organs by which the various secretions or separations are performed; but we must first examine the nature of these secretions.

The *sap* is the principal material of vegetables, since it contains the ingredients that nourish every part of the plant. The basis of this juice, which the roots suck up from the soil, is water; this holds in solution the various other ingredients required by the several parts of the plant, which are gradually secreted from the sap by the different organs appropriated to that purpose, as it passes them in circulating through the plant.

Mucus, or *mucilage*, is a vegetable substance, which, like all the others, is secreted from the sap; when in excess, it exudes from trees in the form of gum.

CAROLINE.

Is that the gum so frequently used instead of paste or glue?

MRS. B.

It is; almost all fruit-trees yield some sort of gum, but that most commonly used in the arts is obtained from a species of acacia-tree in Arabia, and is called *gum arabic*; it forms the chief nourishment of the natives of those parts, who obtain it in great quantities from incisions which they make in the trees.

CAROLINE.

did not know that gum was eatable.

MRS. B.

There is an account of a whole ship's company being saved from starving by feeding on the cargo, which was gum senegal. I should not, however, imagine, that it would be either a pleasant or a particularly eligible diet to those who have not, from their birth, been accustomed to it. It is, however, frequently taken medicinally, and considered as very nourishing. Several kinds of vegetable acids may be obtained, by particular processes, from gum or mucilage, the principal of which is called the *mucous acid.*

Sugar is not found in its simple state in plants, but is always mixed with gum, sap, or other ingredients; this saccharine matter is to be met with in every vegetable, but abounds most in roots, fruits, and particularly in the sugar-cane.

EMILY.

If all vegetables contain sugar, why is it extracted exclusively from the sugar-cane?

MRS. B.

Because it is both most abundant in that plant, and most easily obtained from it. Besides, the sugars produced by other vegetables differ a little in their nature.

During the late troubles in the West-Indies, when Europe was but imperfectly supplied with sugar, several attempts were made to extract it from other vegetables, and very good sugar was obtained from parsnips and from carrots; but the process was too expensive to carry this enterprize to any extent.

CAROLINE.

I should think that sugar might be more easily obtained from sweet fruits, such as figs, dates, &c.

MRS. B.

Probably; but it would be still more expensive, from the high price of those fruits.

EMILY.

Pray, in what manner is sugar obtained from the sugar-cane?

MRS. B.

The juice of this plant is first expressed by passing it between two cylinders of iron. It is then boiled with lime-water, which makes a thick scum rise to the surface. The clarified liquor is let off below and evaporated to a very small quantity, after which it is suffered to crystallize by standing in a vessel, the bottom of which is per-

forated with holes, that are imperfectly stopped, in order that the syrup may drain off. The sugar obtained by this process is a coarse brown powder, commonly called raw or moist sugar; it undergoes another operation to be refined and converted into loaf sugar. For this purpose it is dissolved in water, and afterwards purified by an animal fluid called albumen. White of eggs chiefly consist of this fluid, which is also one of the constituent parts of blood; and consequently eggs, or bullocks' blood, are commonly used for this purpose.

The albuminous fluid being diffused through the syrup, combines with all the solid impurities contained in it, and rises with them to the surface, where it forms a thick scum; the clear liquor is then again evaporated to a proper consistence, and poured into moulds, in which, by a confused crystallisation, it forms loaf-sugar. But an additional process is required to whiten it; to this effect the mould is inverted, and its open base is covered with clay, through which water is made to pass; the water slowly trickling through the sugar, combines with and carries off the colouring matter.

CAROLINE.

I am very glad to hear that the blood that is used to purify sugar does not remain in it; it would be a disgusting idea. I have heard of some

impro[illegible]y the late Mr. Howard, in the process of refining sugar. Pray what are they?

MRS. B.

It would be much too long to give you an account of the process in detail. But the principal improvement relates to the mode of evaporating the syrup, in order to bring it to the consistency of sugar. Instead of boiling the syrup in a large copper, over a strong fire, Mr. Howard carries off the water by means of a large air-pump, in a way similar to that used in Mr. Leslie's experiment for freezing water by evaporation; that is, the syrup being exposed to a vacuum, the water evaporates quickly, with no greater heat than that of a little steam, which is introduced round the boiler. The air-pump is of course of large dimensions, and is worked by a steam engine. A great saving is thus obtained, and a striking instance afforded of the power of science in suggesting useful economical improvements.

EMILY.

And pray how is sugar-candy and barley-sugar prepared?

MRS. B.

Candied sugar is nothing more than the regular crystals, obtained by slow evaporation from a solution of sugar. Barley-sugar is sugar melted by

heat, and afterwards cooled in moulds of a spiral form.

Sugar may be decomposed by a red heat, and, like all other vegetable substances, resolved into carbonic acid and hydrogen. The formation and the decomposition of sugar afford many very interesting particulars, which we shall fully examine, after having gone through the other materials of vegetables. We shall find that there is reason to suppose that sugar is not, like the other materials, secreted from the sap by appropriate organs; but that it is formed by a peculiar process with which you are not yet acquainted.

CAROLINE.

Pray, is not honey of the same nature as sugar?

MRS. B.

Honey is a mixture of saccharine matter and gum.

EMILY.

I thought that honey was in some measure an animal substance, as it is prepared by the bees.

MRS. B.

It is rather collected by them from flowers, and conveyed to their store-houses, the hives. It is the wax only that undergoes a real alteration in

the b[illegible] the bee, and is thence converted into an animal substance.

Manna is another kind of sugar, which is united with a nauseous extractive matter, to which it owes its peculiar taste and colour. It exudes like gum from various trees in hot climates, some of which have their leaves glazed by it.

The next of the vegetable materials is *fecula*; this is the general name given to the farinaceous substance contained in all seeds, and in some roots, as the potatoe, parsnip, &c. It is intended by nature for the first aliment of the young vegetable; but that of one particular grain is become a favourite and most common food of a large part of mankind.

EMILY.

You allude, I suppose, to bread, which is made of wheat-flour?

MRS. B.

Yes. The fecula of wheat contains also another vegetable substance which seems peculiar to that seed, or at least has not as yet been obtained from any other. This is *gluten*, which is of a sticky, ropy, elastic nature; and it is supposed to be owing to the viscous qualities of this substance, that wheat-flour forms a much better paste than any other.

EMILY.

Gluten, by your description, must be very like gum?

MRS. B.

In their sticky nature they certainly have some resemblance; but gluten is essentially different from gum in other points, and especially in its being insoluble in water, whilst gum, you know, is extremely soluble.

The *oils* contained in vegetables all consist of hydrogen and carbon in various proportions. They are of two kinds, *fixed* and *volatile*, both of which we formerly mentioned. Do you remember in what the difference between fixed and volatile oil consists?

EMILY.

If I recollect rightly, the former are decomposed by heat, whilst the latter are merely volatilised by it.

MRS. B.

Very well. Fixed oil is contained only in the seeds of plants, excepting in the olive, in which it is produced in, and expressed from, the fruit. We have already observed that seeds contain also fecula; these two substances, united with a little mucilage, form the white substance contained in the seeeds or kernels of plants, and is destined for the nourishment of the young plant, to which the seed

gives bir... The milk of almonds, which is expressed from the seed of that name, is composed of these three substances.

EMILY.

Pray, of what nature is the linseed oil which is used in painting?

MRS. B.

It is a fixed oil, obtained from the seed of flax. Nut oil, which is frequently used for the same purpose, is expressed from walnuts.

Olive oil is that which is best adapted to culinary purposes.

CAROLINE.

And what are the oils used for burning?

MRS. B.

Animal oils most commonly; but the preference given to them is owing to their being less expensive; for vegetable oils burn equally well, and are more pleasant, as their smell is not offensive.

EMILY.

Since oil is so good a combustible, what is the reason that lamps so frequently require trimming?

MRS. B.

This sometimes proceeds from the construction of the lamp, which may not be sufficiently favourable to a perfect combustion; but there is

certainly a defect in the nature of oil itself, which renders it necessary for the best-constructed lamps to be occasionally trimmed. This defect arises from a portion of mucilage which it is extremely difficult to separate from the oil, and which being a bad combustible, gathers round the wick, and thus impedes its combustion, and consequently dims the light.

CAROLINE.

But will not oils burn without a wick?

MRS. B.

Not unless their temperature be elevated to five or six hundred degrees; the wick answers this purpose, as I think I once before explained to you. The oil rises between the fibres of the cotton by capillary attraction, and the heat of the burning wick volatilises it, and brings it successively to the temperature at which it is combustible.

EMILY.

I suppose the explanation which you have given with regard to the necessity of trimming lamps, applies also to candles, which so often require snuffing?

MRS. B.

I believe it does; at least, in some degree. But besides the circumstance just explained, the com-

mon sorts of oils are not very highly combustible, so that the heat produced by a candle, which is a coarse kind of animal oil, being insufficient to volatilise them completely, a quantity of soot is gradually deposited on the wick, which dims the light, and retards the combustion.

CAROLINE.

Wax candles then contain no incombustible matter, since they do not require snuffing?

MRS. B.

Wax is a much better combustible than tallow, but still not perfectly so, since it likewise contains some particles that are unfit for burning; but when these gather round the wick, (which in a wax light is comparatively small,) they weigh it down on one side, and fall off together with the burnt part of the wick.

CAROLINE.

As oils are such good combustibles, I wonder that they should require so great an elevation of temperature before they begin to burn?

MRS. B.

Though fixed oils will not enter into actual combustion below the temperature of about four hundred degrees, yet they will slowly absorb oxy-

gen at the common temperature of the atmosphere. Hence arises a variety of changes in oils which modify their properties and uses in the arts.

If oil simply absorbs, and combines with oxygen, it thickens and changes to a kind of wax. This change is observed to take place on the external parts of certain vegetables, even during their life. But it happens in many instances that the oil does not retain all the oxygen which it attracts, but that part of it combines with, or burns, the hydrogen of the oil, thus forming a quantity of water, which gradually goes off by evaporation. In this case the alteration of the oil consists not only in the addition of a certain quantity of oxygen, but in the diminution of the hydrogen. These oils are distinguished by the name of *drying oils.* Linseed, poppy, and nut-oils, are of this description.

EMILY.

I am well acquainted with drying oils, as I continually use them in painting. But I do not understand why the acquisition of oxygen on one hand, and a loss of hydrogen on the other, should render them drying?

MRS. B.

This, I conceive, may arise from two reasons; either from the oxygen which is added being less

favourable to the state of fluidity than the hydrogen, which is subtracted; or from this additional quantity of oxygen giving rise to new combinations, in consequence of which the most fluid parts of the oil are liberated and volatilised.

For the purpose of painting, the drying quality of oil is further increased by adding a quantity of oxyd of lead to it, by which means it is more rapidly oxygenated.

The rancidity of oil is likewise owing to their oxygenation. In this case a new order of attraction takes place, from which a peculiar acid is formed, called the *sebacic acid.*

CAROLINE.

Since the nature and conposition of oil is so well known, pray could not oil be actually *made*, by combining its principles?

MRS. B.

That is by no means a necessary consequence; for there are innumerable varieties of compound bodies which we can decompose, although we are unable to reunite their ingredients. This, however, is not the case with oil, as it has very lately been discovered, that it is possible to form oil, by a peculiar process, from the action of oxygenated muriatic acid gas on hydro-carbonate.

We now pass to the *volatile* or *essential oils*. These form the basis of all the vegetable perfumes, and are contained, more or less, in every part of the plant excepting the seed; they are, at least, never found in that part of the seed which contains the embrio plant.

EMILY.

The smell of flowers, then, proceeds from volatile oil?

MRS. B.

Certainly; but this oil is often most abundant in the rind of fruits, as in oranges, lemons, &c. from which it may be extracted by the slightest pressure; it is found also in the leaves of plants, and even in the wood.

CAROLINE.

Is it not very plentiful in the leaves of mint, and of thyme, and all the sweet-smellings herbs?

MRS. B.

Yes, remarkably so; and in geranium leaves also, which have a much more powerful odour than the flowers.

The perfume of sandal fans is an instance of its existence in wood. In short, all vegetable odours or perfumes are produced by the evaporation of particles of these volatile oils.

EMILY.

They are, I suppose, very light, and of very thin consistence, since they are so volatile?

MRS. B.

They vary very much in this respect, some of them being as thick as butter, whilst others are as fluid as water. In order to be prepared for perfumes, or essences, these oils are first properly purified, and then either distilled with spirit of wine, as in the case with lavender water, or simply mixed with a large proportion of water, as is often done with regard to peppermint. Frequently, also, these odoriferous waters are prepared merely by soaking the plants in water, and distilling. The water then comes over impregnated with the volatile oil.

CAROLINE.

Such waters are frequently used to take spots of grease out of cloth, or silk; how do they produce that effect?

MRS. B.

By combining with the substance that forms these stains; for volatile oils, and likewise the spirit in which they are distilled, will dissolve wax, tallow, spermaceti, and resins; if, therefore. the spot proceeds from any of these substances, it

will remove it. Insects of every kind have a great aversion to perfumes, so that volatile oils are employed with success in museums for the preservation of stuffed birds and other species of animals.

CAROLINE.

Pray does not the powerful smell of camphor proceed from a volatile oil?

MRS. B.

Camphor seems to be a substance of its own kind, remarkable by many peculiarities. But if not exactly of the same nature as volatile oil, it is at least very analogous to it. It is obtained chiefly from the camphor-tree, a species of laurel which grows in China, and in the Indian isles, from the stem and roots of which it is extracted. Small quantities have also been distilled from thyme, sage, and other aromatic plants; and it is deposited in pretty large quantities by some volatile oils after long standing. It is extremely volatile and inflammable. It is insoluble in water, but is soluble in oils, in which state, as well as in its solid form, it is frequently applied to medicinal purposes. Amongst the particular properties of camphor, there is one too singular to be passed over in silence. If you take a small piece of camphor, and place it on the surface of a bason of pure water, it will immediately begin to move round

and round with great rapidity; but if you pour into the bason a single drop of any odoriferous fluid, it will instantly put a stop to this motion. You can at any time try this very simple experiment; but you must not expect that I shall be able to account for this phenomenon, as nothing satisfactory has yet been advanced for its explanation.

CAROLINE.

It is very singular indeed; and I will certainly try the experiment. Pray what are *resins,* which you just now mentioned?

MRS. B.

They are volatile oils, that have been acted on, and peculiarly modified, by oxygen.

CAROLINE.

They are, therefore, oxygenated volatile oils?

MRS. B.

Not exactly; for the process does not appear to consist so much in the oxygenation of the oil, as in the combustion of a portion of its hydrogen, and a small portion of its carbon. For when resins are artificially made by the combination of volatile oils with oxigen, the vessel in which the process is performed is bedewed with water, and the air included within is loaded with carbonic acid.

EMILY.

This process must be, in some respects, similar to that for preparing drying oils?

MRS. B.

Yes; and it is by this operation that both of them acquire a greater degree of consistence. Pitch, tar, and turpentine, are the most common resins; they exude from the pine and fir trees. Copal, mastic, and frankincense, are also of this class of vegetable substances.

EMILY.

Is it of these resins that the mastic and copal varnishes, so much used in painting, are made?

MRS. B.

Yes. Dissolved either in oil, or in alcohol, resins form varnishes. From these solutions they may be precipitated by water, in which they are insoluble. This I can easily show you.—If you will pour some water into this glass of mastic varnish, it will combine with the alcohol in which the resin is dissolved, and the latter will be precipitated in the form of a white cloud—

EMILY.

It is so. And yet how is it that pictures or

drawings, varnished with this solution, may safely be washed with water?

MRS. B.

As the varnish dries, the alcohol evaporates, and the dry varnish or resin which remains, not being soluble in water, will not be acted on by it.

There is a class of compound resins called *gum-resins*, which are precisely what their name denotes, that is to say, resins combined with mucilage. Myrrh and assafœtida are of this description.

CAROLINE.

Is it possible that a substance of so disagreeable a smell as assafœtida can be formed from a volatile oil?

MRS. B.

The odour of volatile oils is by no means always grateful. Onions and garlic derive their smell from volatile oils, as well as roses and lavender.

There is still another form under which volatile oils present themselves, which is that of *balsams*. These consist of resinous juices combined with a peculiar acid, called the benzoic acid. Balsams appear to have been originally volatile oils, the oxygenation of which has converted one part into a resin, and the other part into an acid, which,

combined together, form a balsam; such are the balsams of Peru, Tolu, &c.

We shall now take leave of the oils and their various modifications, and proceed to the next vegetable substance, which is *caoutchouc*. This is a white milky glutinous fluid, which acquires consistence, and blackens in drying, in which state it forms the substance with which you are so well acquainted, under the name of gum-elastic.

CAROLINE.

I am surprised to hear that gum-elastic was ever white, or ever fluid! And from what vegetable is it procured?

MRS. B.

It is obtained from two or three different species of trees, in the East-Indies, and South-America, by making incisions in the stem. The juice is collected as it trickles from these incisions, and moulds of clay, in the form of little bottles of gum-elastic, are dipped into it. A layer of this juice adheres to the clay and dries on it: and several layers are successively added by repeating this till the bottle is of sufficient thickness. It is then beaten to break down the clay, which is easily shaken out. The natives of the countries where this substance is produced sometimes make shoes and boots of it by a similar process, and

they are said to be extremely pleasant and serviceable, both from their elasticity, and their being water-proof.

The substance which comes next in our enumeration of the immediate ingredients of vegetables, is *extractive matter.* This is a term, which, in a general sense, may be applied to any substance extracted from vegetables; but it is more particularly understood to relate to the extractive *colouring matter* of plants. A great variety of colours are prepared from the vegetable kingdom, both for the purposes of painting and of dying; all the colours called *lakes* are of this description; but they are less durable than mineral colours, for, by long exposure to the atmosphere, they either darken or turn yellow.

EMILY.

I know that in painting, the lakes are reckoned far less durable colours than the ochres; but what is the reason of it?

MRS. B.

The change which takes place in vegetable colours is owing chiefly to the oxygen of the atmosphere slowly burning their hydrogen, and leaving, in some measure, the blackness of the carbon ex-